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REMEDIAL INVESTIGATION

VOLUME I - TEXT

REICH FARM SITE
PLEASANT PLAINS
DOVER TOWNSHIP, NEW JERSEY

EPA WORK ASSIGNMENT
NUMBER 94-2L49
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EXECUTIVE SUMMARY

Purpose of the Remedial Investigation

The objectives of the Remedial Investigation (RI) at the Reich Farm Site in Ocean County, New Jersey, are as follows:

- To determine the presence and nature of contaminants at the Reich Farm Site, including groundwater contamination, surface and subsurface soil contamination, and the existence of buried drums.
- To determine the extent of migration of contaminants from the site.
- To identify potential receptors of groundwater contamination from the site.
- To identify possible remedial measures necessary to mitigate the potential threat from any onsite or offsite contamination.

The information gathered during this study will need to be supplemented with a Phase II RI in order to fulfill all of the above objectives. The data gathered to meet these objectives will then be used to perform the Feasibility Study of Remedial Alternatives.

Site Description, Background, and Problems

The Reich Farm Site is located in east-central New Jersey in Ocean County, about 35 miles southeast of Trenton, New Jersey. The site consists of an open relatively flat, sandy surface less than three acres in area. The site is bordered on the north and east by thickly wooded areas and on the south and west by two commercial buildings. Surface elevations at the site range from 70 to 68 feet above mean sea level, with a slight slope to the west, southwest.

In March 1971, Union Carbide Corporation (UCC) contracted with Mr. Nicholas Fernicola, an independent waste hauler, to remove drums containing chemical wastes from its manufacturing facility. From August to December 1971, Mr. Fernicola transported many of the drums to a parcel of land in Pleasant Plains which he leased from Mr. Samuel Reich. A few months after Mr. Fernicola commenced his operations at the site, the Reichs noticed that unusual odors emanating from the

portion of the property and in December the Reichs investigated the area and discovered approximately 4,500 drums containing chemical wastes and 450 empty drums. The drums bore UCC labels. In addition, they discovered a number of trenches into which chemical wastes had been discharged. These drums were labeled as "tar Pitch," "lab waste solvents," "blend of resin and oil," "solvent washes of process equipment." The proper authorities were notified and a complaint was filed against Mr. Fernicola and UCC. By February 29, 1972, all visible drums and trench wastes had been removed from the site.

Early in 1974, some Pleasant Plains area residents discovered an unusual taste and odor in their well water. Subsequent laboratory testing of these and other wells revealed the presence of petrochemical contaminants. The private wells were then condemned. In the wake of the wide spread publicity which accompanied the groundwater contamination, municipal officials in Dover Township received a "tip" that more drums might be buried at Reich Farm than had been removed during the 1972 cleanup operation. Another 51 drums and a large quantity of waste that were buried on the property were discovered and subsequently removed.

Between July 30 and August 27, 1974, the Dover Board of Health ordered the closing of 148 private wells drawing from the contaminated Cohansey aquifer. Alternative water supplies were provided. Initially, water was trucked in; eventually, resident homes were connected to municipal water supplied by the Toms River Water Company. In April 1976, organic contamination was found in an additional 13 domestic wells. These wells were ordered closed. In some sections of the area, where construction of new wells was still allowed, the wells had to be constructed to a greater depth to obtain uncontaminated water from the Kirkwood aquifer.

On April 21, 1977, Union Carbide Corporation signed a Consent Order with the New Jersey Department of Environmental Protection (NJDEP), agreeing to pay the State up to \$60,000. In June 1977, the NJDEP dropped charges against Nicholas Fernicola, in return for Mr. Fernicola's agreeing to cease hauling and disposing of chemical wastes. Mr. Fernicola agreed to pay a \$100 settlement.

On August 6, 1982, the Mitre Model was completed for the site, giving the site a migration route score of 53.48 out of a possible 100. The Reich Farm Site was listed on the EPA's Proposed National Priorities List of 419 Superfund sites issued in December 1982.

An active commercial stone crushing operation currently occupies the site. No evidence of waste related activities is present on the site surface.

Scope of This Remedial Investigation

The remedial investigation work that has been conducted by IMS Engineers, at the site includes the activities listed below.

- Reconnaissance survey of the site.
- Geophysical Survey to indicate the soil sampling locations.
- Survey work to locate the boundaries of the Reich Farm and the adjoining properties.
- Drilling and sampling of surface and subsurface soils.
- Sampling of existing residential wells, municipal wells and one monitoring well in the vicinity of the site.
- " ● Surveying of onsite and offsite sampling locations, monitoring wells, and an onsite sampling grid.
- Monitoring well sampling.
- Aquifer pumping test.

Groundwater and soil samples were analyzed for the Hazardous Substance List (HSL) compounds and geochemical parameters, such as carbonate, bicarbonate, chloride, and nitrate. Water levels were measured in the monitoring wells on a regular basis during field activities. Some portions of the analytical data base used in this report are still being validated; therefore, this should be considered a preliminary RI report..

Major Findings

- The fill material encountered during drilling on the site property consists primarily of silty sand and gravel.
- The thickness of the vadose zone underlying the fill areas is greater than 15 feet.
- Silt and clay content increases with depth from the Cohansey Formation to the underlying Kirkwood Formation.
- In the study area, groundwater flow direction in the water table aquifer is to the south and the groundwater flow gradient increases from the north to the south across the study

area. Both of these factors could be attributed to an influence that the Toms River Water Company wells may have on the groundwater flow system beneath the site.

- A slight downward vertical gradient exists between wells screened in the Cohansey Water Bearing Formation and wells screened in the Kirkwood Water Bearing Formation.
- A direct hydraulic connection exists between the Cohansey and Kirkwood Water Bearing Formations.
- The average groundwater seepage velocity for the Cohansey Water Bearing Formation was calculated to be 0.93 feet/day (340 feet/year).
- 1,1,1 - Trichloroethane, trichloroethene, and tetrachloroethene are the major groundwater contaminants in the area.
- Soils, from 0 to 20 feet, throughout the site, are contaminated with varying levels of organics (volatiles and semi-volatiles), PCBs, and pesticides, may present a continuous source of groundwater contamination as contaminants are leached by infiltration of precipitation.
- The major potential health risk at the site is associated with exposure to contaminated groundwater. Lifetime exposure to the concentrations observed in monitoring well samples may be associated with adverse health implications. However, there is no data that indicate human receptors in the immediate vicinity of the site are exposed to these constituents.
- Constituents detected in residential well and/or municipal well samples are of concern. Insufficient data are available to determine if these compounds are site-related.
- Direct contact with, or accidental ingestion of, contaminated onsite surface soils and inhalation of ambient air poses no appreciable risks to human receptors.
- Environmental receptors are unlikely to be impacted by site contaminants. The relatively low concentrations of HSL organic and inorganic constituents detected in surface soils and onsite activities suggests the potential for impacts to terrestrial biota are minimal.

Data Problems and Unresolved Data Needs

- The sampling program needs to be expanded for the site property in order to further delineate sources of contamination. Test pit excavation is also recommended.
- A domestic and municipal well survey is needed in order to determine the possibility of using these wells as data points in a Phase II remedial investigation, particularly for determining regional groundwater flow directions and groundwater quality.
- A long-term pumping test is needed in the Kirkwood Water Bearing Formation in order to determine aquifer characteristics of the Kirkwood.
- Additional monitoring wells are recommended in the vicinity of the Toms River Water Company.
- A more comprehensive review of existing information is needed in order to delineate additional data needs.

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) issued the work assignment for the Remedial Investigation/Feasibility Study (RI/FS) at the Reich Farm Site, New Jersey, in September, 1984 under Contract Number 68-01-6699 (to NUS Corporation) and work Assignment Number 94-2L49.0. NUS Corporation subcontracted the assignment to IMS Engineers-Architects P.C. (IMS) a small disadvantaged business. This report presents the results of the RI activities conducted by IMS.

The objectives of the RI at the Reich Farm Site as outlined in the Work Plan were as follows:

- To determine the presence and nature of contaminants at the Reich Farm Site, including groundwater contamination, surface and subsurface soil contamination, and the existence of buried drums.
- To determine the extent of migration of contaminants from the site.
- To identify potential receptors of groundwater contamination from the site.
- To identify possible remedial measures necessary to mitigate the potential threat from any onsite or offsite contamination.

During this remedial investigation data was acquired to determine whether groundwater contamination is currently present in the area, and to more fully characterize the nature and concentration of the contaminants. In addition, initial sampling was conducted to determine the current extent of migration of the groundwater contamination offsite. In order to better evaluate the current extent of migration of contamination, and to provide additional facts necessary for preparing the feasibility study, a Phase II RI is recommended. The recommendations are discussed throughout the report and are summarized in the Executive Summary.

1.1 Site Background Information

1.1.1 Location

The Reich Farm Site is located in east-central New Jersey in Ocean County, about 35 miles southeast of Trenton, New Jersey. The site is approximately 800 feet southeast of the intersection of Church and Lakewood Roads in the Pleasant Plains section of Toms River, New Jersey. The approximate map coordinates for the site location are 40° 00' 30" north latitude and 74° 13' 00" west longitude. The site area is shown on Figure 1-1 (USGS 1971).

1.1.2 Site Layout

The site consists of an open relatively flat, sandy surface less than three acres in area. The site is bordered on the north and east by thickly wooded areas and on the south and west by two commercial buildings. Surface elevations at the site range from 70 to 68 feet above mean sea level, with a slight slope to the west, southwest.

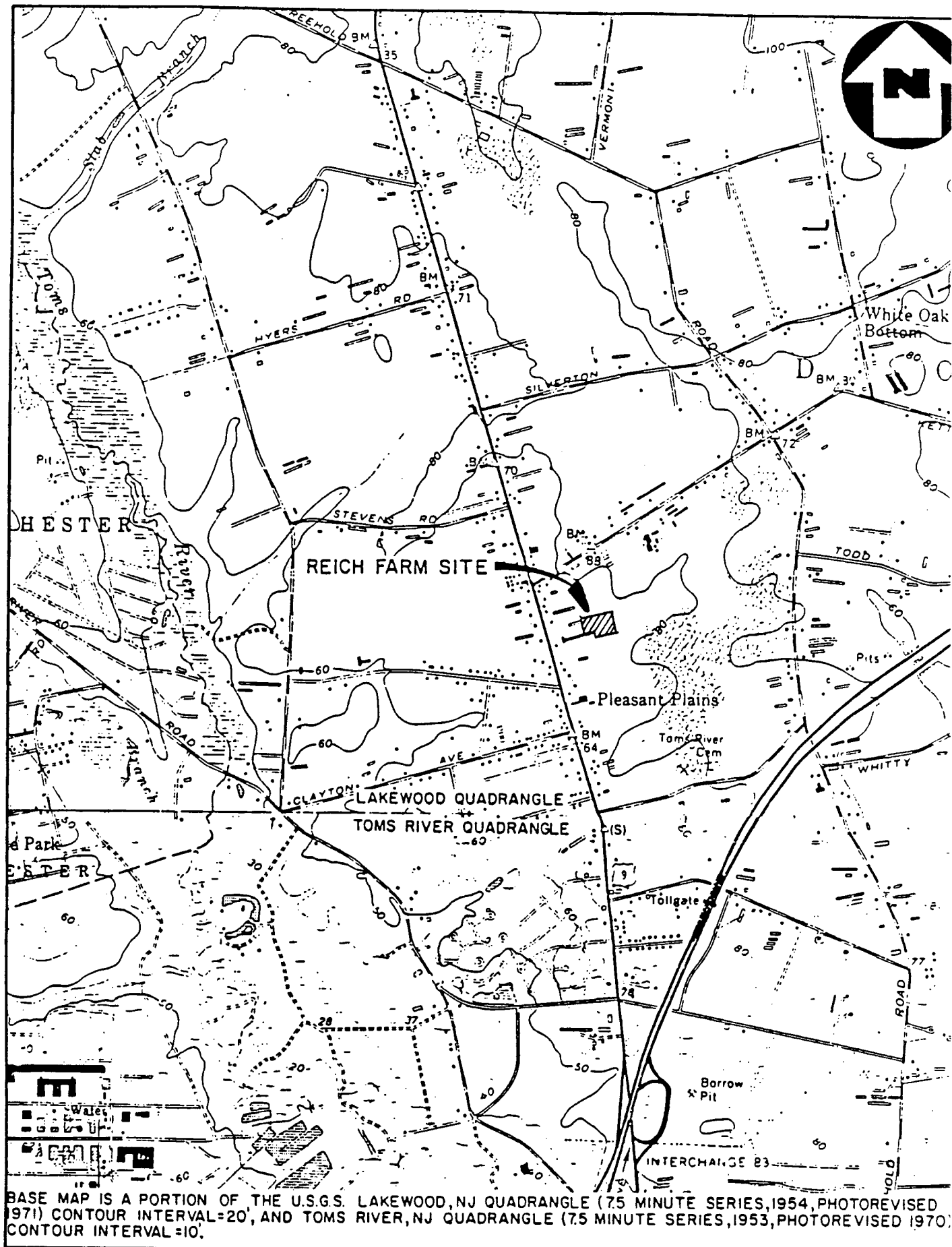
An active commercial stone crushing operation currently occupies the site. No evidence of waste related activities is present on the site surface. Several piles of crushed stone and construction debris up to 8 feet high occupy the east end of the site. The west end is occupied by storage and office trailers, large stone crushing machinery, underground diesel and gasoline tanks, and by parking areas. A map of the site and the boundaries of the area in which waste related activities have occurred is shown in Figure 1-2.

1.1.3 Historical Description

The following site historical description is drawn primarily from the TRW Systems Group report (1976). Detailed Dover Township records regarding the past Township response to the problem are no longer in Township files and have presumably been purged. Other sources of information were the New Jersey Department of Environmental Protection (NJDEP) and personal interviews.

1.1.3.1 Chronology of Waste-Related Activities

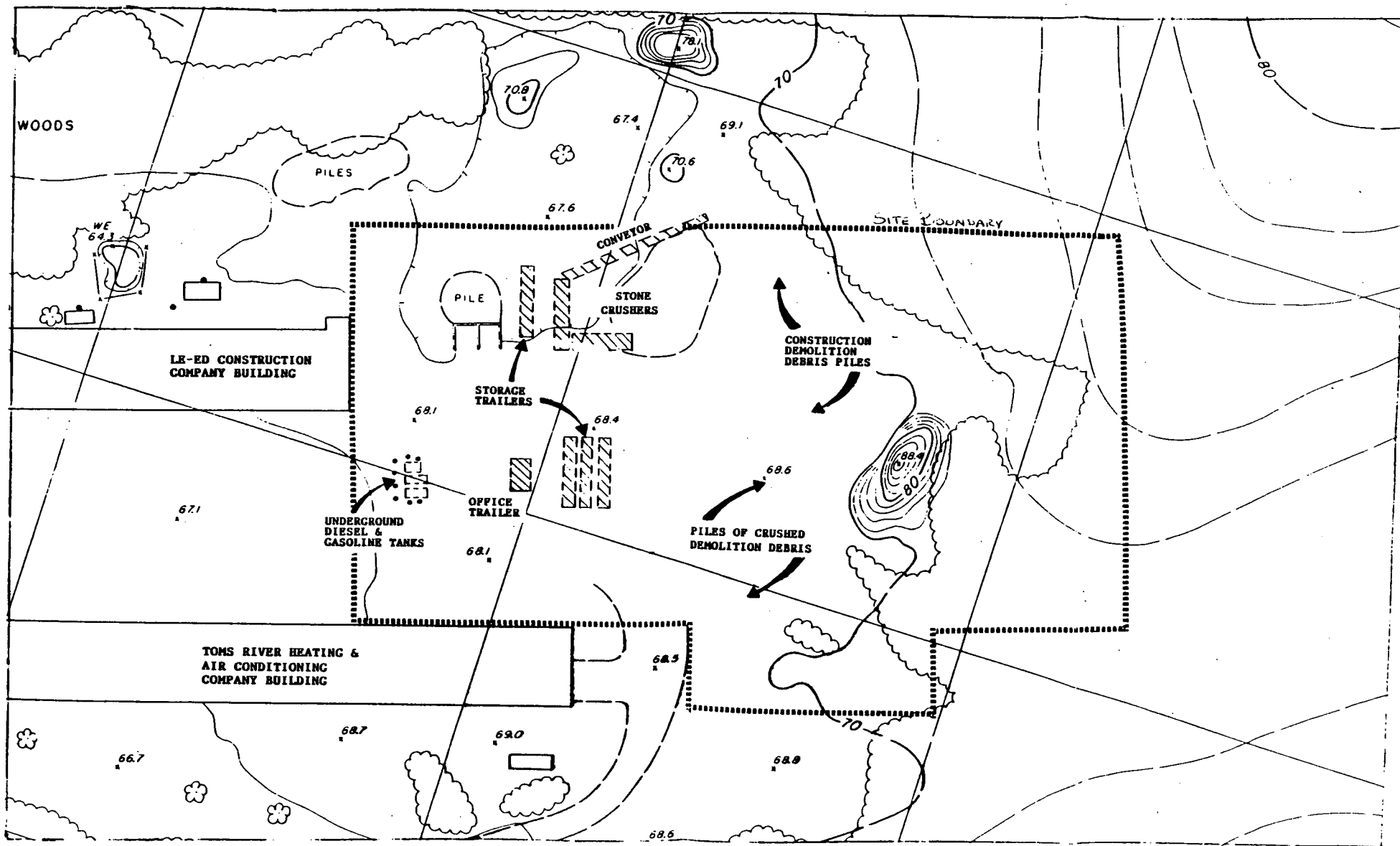
In March 1971, Union Carbide Corporation (UCC) contracted with Mr. Nicholas Fernicola, an independent waste hauler, to remove drums containing chemical wastes from its manufacturing facility in Bound Brook, New Jersey, and to transport them to the Dover Township Municipal Landfill



AREA MAP
REICH FARM SITE, PLEASANT PLAINS, NJ
 SCALE: 1"=2000'

1-3

IMS
 ENGINEERS - ARCHITECTS, P.C.
 115 Metro Park
 Rochester, NY 14623
 FIGURE 1-1



SITE FEATURES MAP

REICH FARM SITE, DOVER TWP., NJ
Scale: 1" = 50'

IMS

ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE

in Dover Township, New Jersey (a sanitary landfill) for ultimate disposal. The wastes consisted of organic wash solvents and still bottoms and residues from the manufacturing of organic chemicals, plastics and resins.

Descriptions of the drum contents provided by Union Carbide Corporation (TRW, 1976) are very general (e.g. "tar pitch," "lab waste solvents," "blend of resin and oil," "solvent washes of process equipment") and do not identify specific chemical constituents of the waste material. It is clear from the lists, however, that the wastes contained aromatic hydrocarbons, phenols, halogenated aliphatic hydrocarbons, certain polymeric resins, and unspecified petrochemicals.

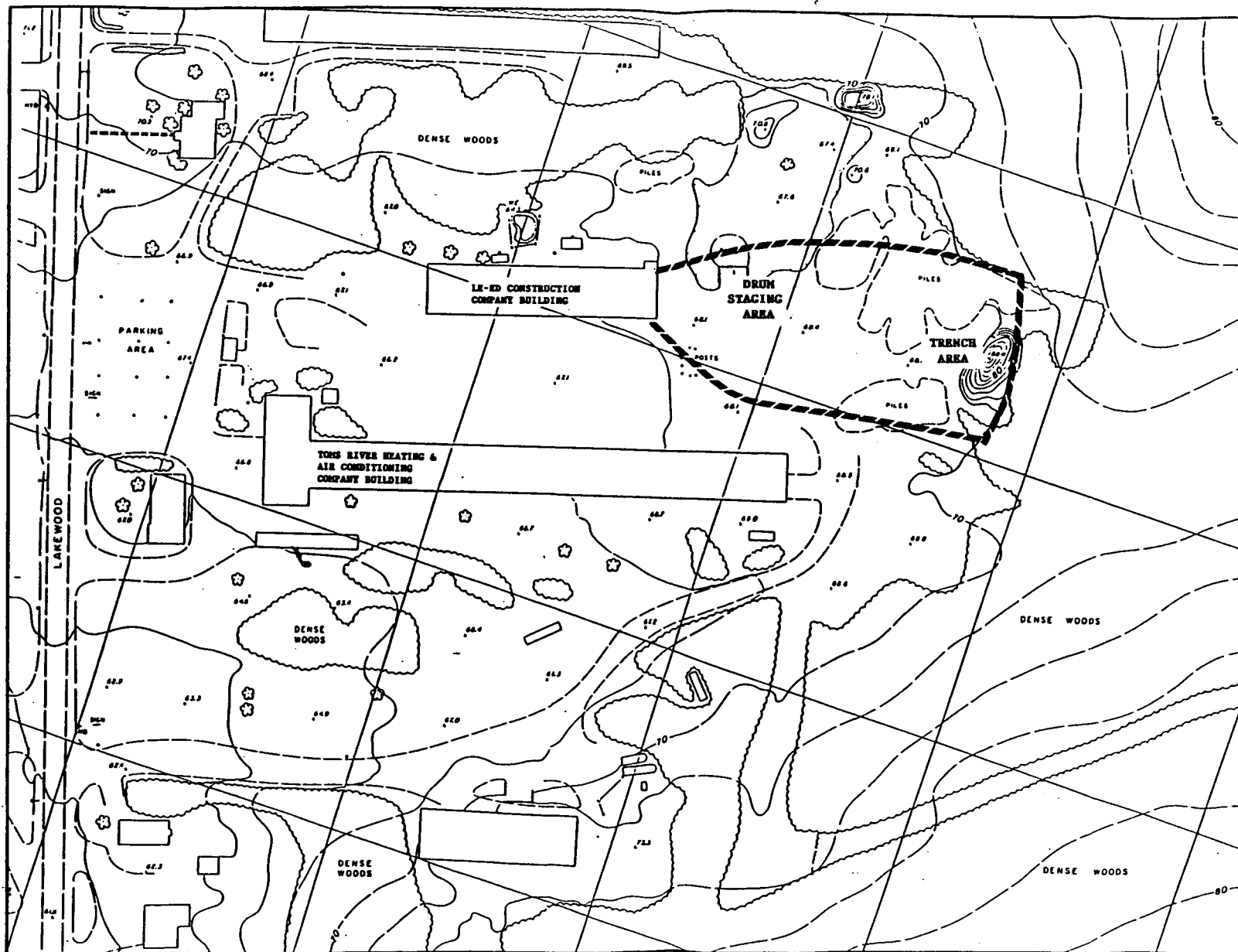
From August to December 1971, Mr. Fernicola transported many of the drums to a 1 to 2 acre area in Pleasant Plains, which he leased from Mr. Samuel Reich. A few months after Mr. Fernicola commenced his operation at the site, the Reichs noticed that unusual odors were emanating from that portion of the property. In December, 1971 the Reichs investigated the area and discovered approximately 4,500 drums containing chemical wastes and 450 empty drums. The drums bore UCC labels. In addition, they discovered a number of trenches into which chemical wastes had been discharged. The approximate locations of the drum staging area and the trenching area are shown in Figure 1-3.

The Reichs notified both the NJDEP and UCC of their discovery, and requested that UCC and Mr. Fernicola remove the drums and clean up the property. Union Carbide ordered Mr. Fernicola to discontinue removing drums from the Union Carbide Bound Brook facility.

On January 31, 1972, the attorney for Mr. and Mrs. Reich filed a complaint against Mr. Fernicola and Union Carbide in State Superior court. The court ordered the defendants to cease dumping and to remove all wastes and drums from the Reichs property. In February 1972, removal of the drums from the site began.

In February 1972, Union Carbide had removed approximately 5,096 drums from the Reich property. All visible drums and trench wastes had been removed from the Reich Farm Site. The company maintained that it believed the premises had been cleared of all chemical wastes at this time. In April 1972, Union Carbide paid \$10,000 to the Reichs for damages to property and for the cost of a new water well.

Early in 1974, some Pleasant Plains area residents discovered an unusual taste and odor in their well water. Subsequent laboratory testing of these and other wells revealed the presence of



*Mr. Edward Steitz, personal
communication, 1985.

AREA OF WASTE RELATED ACTIVITIES 1971*
REICH FARM SITE, DOVER TWP., NJ
1" = 90'

IMS
ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE 1-3

petrochemical contaminants. The private wells were then condemned. In the wake of the widespread publicity which accompanied the groundwater contamination, municipal officials in Dover Township received a "tip" that drums might be buried at Reich Farm that had not been unearthed during the 1972 cleanup operation.

In June 1974, representatives of Dover Township uncovered 51 buried drums and large quantities of buried wastes on the Reich property. These drums and 1,000 cubic yards of contaminated soil were subsequently removed from the site.

Between July 30 and August 27, 1974, the Dover Board of Health ordered the closing of 148 private water wells drawing from the contaminated Cohansey aquifer. Residents homes were connected to municipal water supplied by the Toms River Water Company. In April 1976, organic contamination was found in an additional 13 domestic wells. These wells were ordered closed. In some sections of the area, where construction of new wells was still allowed, the wells had to be constructed to a greater depth to obtain uncontaminated water from the Kirkwood aquifer. (A review of the available analytical data failed to show a definite pattern of groundwater contamination attributable to the Reich Farm Site.) Two permanent monitoring wells were installed near the Toms River Water Company (TRWC) Parkway Municipal Wellfield. Annual sampling of these two wells occurred between 1976 and 1980.

On August 6, 1982, the Mitre Model was completed on the site, giving the site a migration route score of 53.48 out of a possible 100. The Reich Farm Site was listed on the EPA's Proposed National Priorities List of 418 Superfund sites issued in December 1982.

1.1.3.2 Summary of Past Groundwater Sampling Programs

Groundwater contamination in Pleasant Plains was delineated on the basis of four sampling programs conducted between March and November of 1974:

- March 14 to July 18, 1974. Total organics in ether extractables. (See Table 1-1 for results.)
- June 19 to July 18, 1974. Total organics in carbon chloroform extract. (See Table 1-2 for results.)

TABLE 1-1
GROUNDWATER SAMPLING IN PLEASANT PLAINS
MARCH 14-JUNE 17, 1974
REICH FARM SITE, NEW JERSEY

Sample Location		Total Organics (ppm)*
Lakewood Road	Monroe Avenue to Church Road	Negative to 18 ppm
Church Road	Lakewood Road to Old Freehold Road	Negative to 9.5
Sunset	Lakewood Road to Whitesville Road	1.1 to 5.2
Clayton Avenue	Lakewood Road to Whitesville Road	Negative to 21.3
Caroline	Clayton to Sunset	4.1 to 4.2
Monroe	Lakewood Road to Sunset	2.8 to 6.6
Lena Avenue		Negative

*The organics were removed from water by adsorption on activated carbon; the spent carbon was then dried and eluted with ether to recover and determine gravimetrically the quantity of the adsorbed organics.

TABLE 1-2
GROUNDWATER SAMPLING IN PLEASANT PLAINS
JUNE 19-JULY 20, 1974
REICH FARM SITE, NEW JERSEY

Sample Location		Total Organics (ppm)*
Pl. Plains Fire Department	60 Clayton	0.4
Toms River Water Company - Well No. 20	Whitesville Road	0.1
Nelson Residence	1532 Lakewood	1.2
First Aid Building	52 Clayton Avenue	0.4
North Dover Elementary School	Church Road	0.1
Toms River Water Company - Well No. 26	Parkway Wellfield	0.2

*Determined gravimetricly from Carbon Chloroform extraction. Standard method 506.

TABLE 1-3
GROUNDWATER SAMPLING IN PLEASANT PLAINS
JULY 11, 1974
REICH FARM SITE, NEW JERSEY

Sample Location		Volatile Organics by GC/MS
Toms River Water Company - Well No. 20	Parkway Wellfield	0.1 ppb Volatile Organics
Ocean County Agricultural Building	Sunset Avenue	0.1 ppb Volatile Organics
North Dover, Elementary School	Church Road	0.1 ppb Volatile Organics
Nelson Residence	1532 Lakewood Road	12 ppb Toluene 30 ppb Styrene

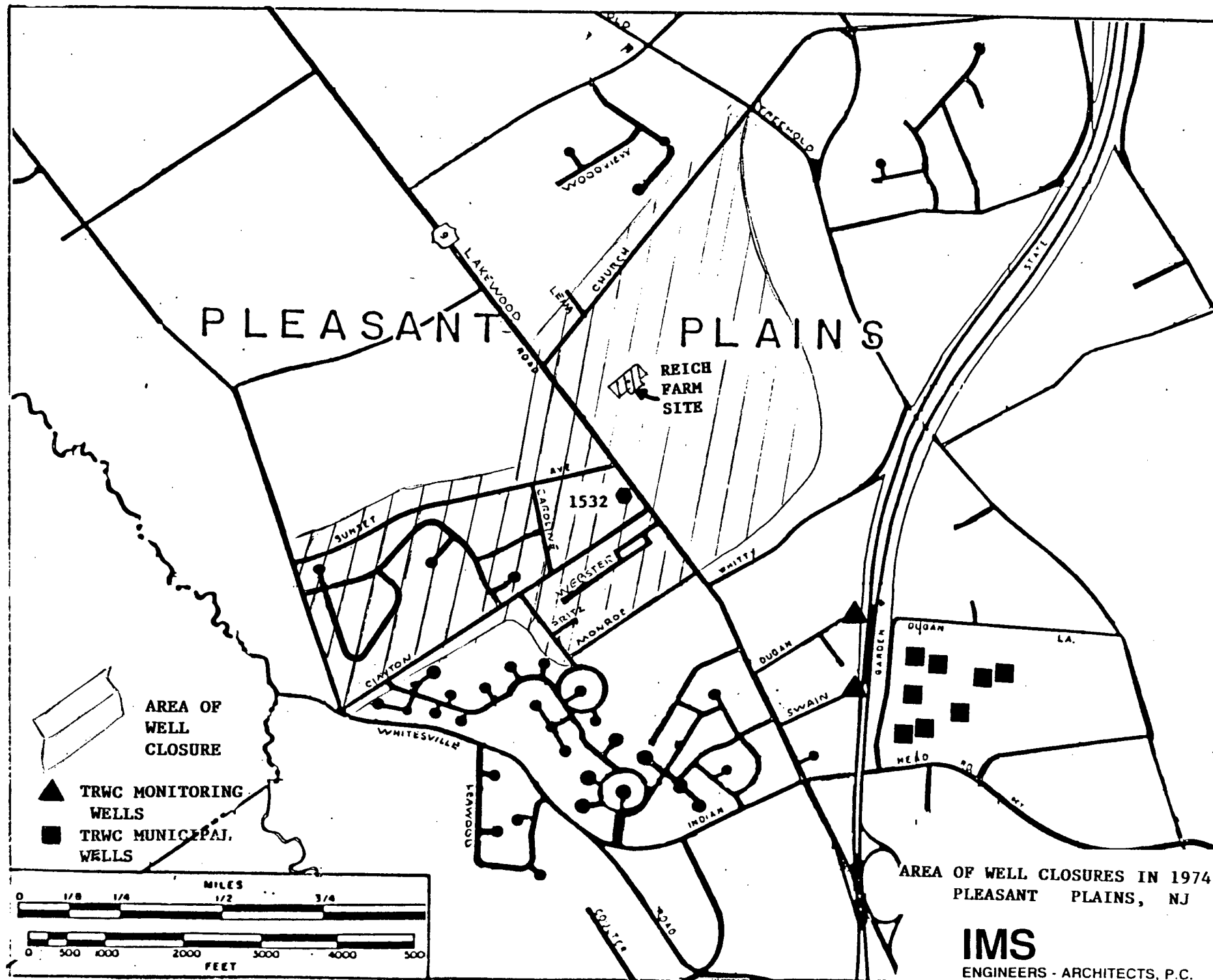
- July 11, 1974. GC/MS analysis for volatile organics. (See Table 1-3 for results.)
- July 31 to November 9, 1974. Total organics by carbon tetrachloride extraction/IR absorption.

From March to July 11, 1974, the area of sampling was confined to areas where complaints were registered, or where previous sampling had demonstrated contaminated water. In August, 1974 the sampling was extended to a radius of 1 to 1-1/2 miles from the Reich Farm Site. A review of this data failed to show a definite pattern of groundwater contamination attributable to the Reich Farm Site. Levels of total organics in the July 31 to November 9 program ranged from negative to 1.9 ppm. The most contaminated well exhibiting 1.9 ppm total organics, 30 ppb styrene, and 12 ppb toluene was located at 1532 Lakewood Road approximately 1,200 feet south-southwest of the site (see Figure 1-4.). Earlier in March of 1974, toluene was reported detected in an adjacent well, but analytical specifics are unknown.

On the basis of sampling results obtained through July 18, 1974, the State Bureau of Potable Water ordered Dover Township to prohibit groundwater use for drinking on both sides of the following streets:

Street	From	To
Lakewood Road	Monroe Avenue	Church Road
Church Road	Lakewood Road	Old Freehold Road
Sunset Road	Lakewood Road	Whitesville Road
Clayton Avenue	Lakewood Road	Whitesville Road
Carolina Avenue	Clayton Avenue	Sunset Road
Monroe Avenue	Lakewood Road	Clayton Road

On September 16, 1974 the Township of Dover also ordered wells closed along both sides of Webster Road, Lena Avenue and Fritz Drive. Wells were ordered sealed pending the introduction of water mains. A zone system restricting groundwater use was established. Zone I encompasses the area of closed wells; all new wells are prohibited. Zone II is peripheral to Zone I. No wells are permitted in the water table aquifer in Zone II, but are required to be in deeper aquifers.



In total, 148 wells were condemned along the streets listed previously. A plan view of the area with closed wells is shown in Figure 1-5 with superimposed regional groundwater contours, based on 1974 conditions. Figure 1-5 shows that over one-half of the restricted zones were hydraulically upgradient of the Reich Farm Site in 1974. This is corroborated by current on site water elevations determined in the RI.

While specific chemicals detected in wells downgradient of the site were a cause for concern, and in the absence of other known sources, can be attributed to the Reich Farm Site, the widespread and comparatively low levels of total organics reported in the data did not define a contaminant plume.

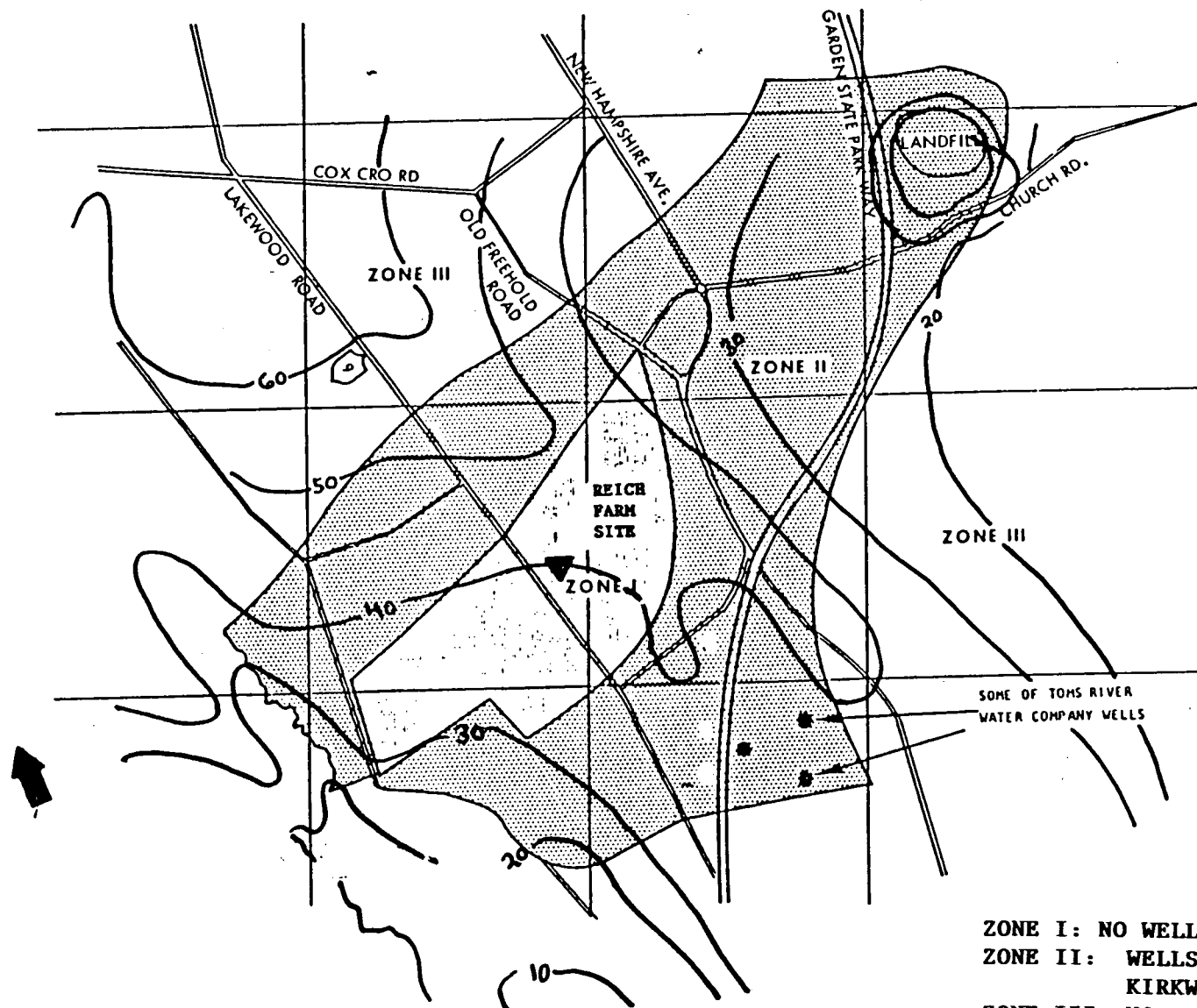
In March of 1976, phenol was found in 9 out of 15 wells along Dugan and Wallach Lanes. Phenol concentrations ranged from 0.01 to 5.9 ppm. Wells on both streets were ordered closed. It is not certain that the phenol derived from a contaminant plume originating at the Reich Farm Site.

Permanent monitoring wells were installed on Dugan Lane and Swain Road (see Figure 1-4) to monitor movement and contaminants toward the Toms River Water Company (TRWC) municipal production wells at the Parkway Wellfield.

1.1.3.3 Delineation of Waste Disposal Areas

The limits of the drum dumping area are indicated in Figure 1-3. A 1972 aerial photograph was utilized to determine the former position of the tree line defining the northern boundary of the open area adjacent to the commercial buildings. The former tree line and the present foundation of the Le-Ed Construction Company building defined the northern and western extent of the drums on the site surface in 1971-72 the eastern extent was approximately the 1972 tree line, and the southern extent was limited by the parking area along the north side of the Toms River Heating and Air Conditioning building (Mr. Edward Steitz, personal communication, 1985).

In 1974, Dover Township investigated the site as a potential source of the groundwater contamination discovered in area wells. Whatever documentation that was produced as a result of the work that was performed, has been destroyed in a file purge at the Township offices. The following general information was obtained regarding this work (Mr. Albert Gabriel, personal communication, 1985).



ZONE I: NO WELLS PERMITTED
 ZONE II: WELLS SCREENED IN THE
 KIRKWOOD OR DEEPER
 ZONE III: NO RESTRICTIONS
 (TRW, 1976)

GROUNDWATER CONTOURS AND ZONES OF
 RESTRICTED GROUNDWATER USE IN
 PLEASANT PLAINS, NJ, 1974.

IMS
 ENGINEERS - ARCHITECTS, P.C.
 115 Metro Park
 Rochester, NY 14623
 1-5

- Additional drums (55 gallon) were excavated in trenches located approximately as shown in Figure 1-3.
- A trench containing glass waste containers was also discovered.
- The steel drums were located with a metal detector, having an effective depth of about 4 to 6 feet. The trench of glass bottles was located with the aid of Mr. Fernicola.
- No analytical work was performed on the soils. Soils were removed from the site on the basis of odor and visual evidence of contamination.
- The maximum depth of soil excavation was approximately 16 feet.
- Prior to the remedial action surface soils were saturated with liquid waste.

1.1.4 Existing Water Supply Wells

Groundwater is the primary source of water in the Pleasant Plains section of Toms River. Wells in the immediate vicinity of the site were closed by Township decree in 1974-1976. Municipal water lines were extended throughout the downgradient area. The Township decree required well closures and prohibits new wells within Zone I, in close proximity to the site. Within Zone II, peripheral to Zone I, new wells are required to be screened within the deep aquifer.

A well survey was conducted for this project to identify potable domestic wells in Zone I, which could be affected by contamination currently at the Reich Farm Site. Two irrigation wells occur within Zone I, both in the Cohansey; however, no potable wells are known to be currently in use in Zone I. The well survey and subsequent sampling was extended further from the site to determine, to the extent possible from existing wells, whether a contaminant plume, with its source at the Reich Farm Site, is currently affecting the groundwater quality.

Portions of Zone II downgradient of or southeast to south-southwest of the site were deemed of particular interest. Excluding the Parkway Wellfield, only two potable wells were identified in this direction, both in the deep aquifer.

The Toms River Water Company (TRWC) currently supplies municipal water from eight production wells located at the Parkway Wellfield, with a total wellfield pumping capacity is 5.75 million gallons per day. The wellfield is situated between 4,500 and 5,500 feet southeast of the Reich Farm Site.

Portions of Zone II located northwest to northeast and east of the site were also surveyed. The well nearest to the site is 1,300 feet to the west-northwest along Lakewood Road. All residences and businesses in Zone II north of Church Road and east of Old Freehold Road have private wells.

Numerous private wells are located along Coulter and Whitesville Roads outside of the southern boundary of Zone II at a distance of 5,500 to 8,000 feet from the site. The Toms River Water Company maintains a Cohansey production well at the intersection of Indian Head and Whitesville Roads, about 5,700 feet from the site.

1.1.5 Physiography

The Reich Farm Site is located in the Atlantic Coastal Plain physiographic province. The topography of the region consist of a gently undulating plain with low relief. The site is situated on an interfluvial highland area, 1.3 miles from the Toms River. No surface drainage to the Toms River occurs within 0.75 miles from the site. Streams throughout Ocean County have dendritic drainage patterns. Surface elevations in the vicinity of the site range from 70 to 80 feet above mean sea level. The surface at the site has a slight slope to the west-southwest.

1.1.6 Climate

The climate of New Jersey is characterized as continental. Large-scale weather patterns normally move eastward across the are. The proximity of the Atlantic Ocean results in localized modifications to the overall temperature, wind, and rainfall patterns from the differential heating and cooling of the land and sea.

Precipitation totals generally are well distributed throughout the year. However, year-to-year variations in amounts recorded in late summer and early autumn may result from the northward passage of storms originating in the tropics. In years that these seasonal storms are experienced, annual precipitation totals tend to be higher than normal. Toms River registers its highest average monthly precipitation total in August (4.98 inches) and its lowest in June (3.41 inches).

Monthly climatological data for temperature and precipitation at Freehold, New Jersey is presented in Table 1-4. The Freehold meteorological station is located in Monmouth County, 20 miles north of the Reich Farm Site. Climatological data for precipitation at Toms River also are presented in Table 1-4; temperature is not measured at the Toms River station. Data presented are based on records of the 30-year period 1951-1980, inclusive, the time period routinely employed to compute climatological norms.

1.1.7 Current Land Use

The land areas directly adjacent to the site are predominantly undeveloped, with some commercial development to the west. A series of businesses are present west of the site. In the general vicinity of the site, agricultural and residential land use predominates. The population density in the immediate vicinity of the site is low. Approximately 563 persons within a 1/4 -mile radius of the site were estimated by the Mitre Model to be affected before any remedial activities were implemented. The population served by groundwater within a 3-mile radius of the site is approximately 106,500.

The area of the site formally rented to Nicholas Fernicola, is now rented by the Reichs to the Le-Ed Construction Company, who primary business is the sale of cement and cement products. The Le-Ed Company also crushes demolition debris for resale as construction aggregate material. Approximately, 30 percent of the site surface has piles of aggregate material brought in from off site and eventually transported after crushing, to off site locations. Another 15 percent of the site surface is covered by semi-permanent storage/and office trailers, and by the crushing machinery or associated equipment. The later 15 percent was not accessible to investigation during the RI.

The building along the sites southern boundary is occupied by an automobile restoration firm and by the Toms River Heating and Air Conditioning Company.

1.2 Nature and Extent of the Problem

The current situation and potential receptors are summarized below.

1.2.1 Current Situation

Site Surface and Subsurface

The site surface is currently free of discarded drums or other visual evidence of contamination.

TABLE 1-4
AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION
FREEHOLD, NEW JERSEY
(1951-1980)

Month	Temperature (°F)	Precipitation (Inches)	Precipitation (Inches) at Toms River, New Jersey
January	30.5	3.55	3.55
February	32.0	3.28	3.42
March	40.1	4.44	4.28
April	50.8	3.66	3.95
May	60.6	3.75	3.61
June	69.5	3.47	3.41
July	74.2	4.04	4.65
August	72.9	4.64	4.98
September	66.2	3.67	3.98
October	55.4	3.52	3.91
November	45.4	3.96	3.92
December	34.6	3.91	4.22
Annual	52.7 (Avg.)	45.89 (Total)	47.68 (Total)

*Average monthly precipitation at Toms River, New Jersey.

Source: National Oceanic and Atmospheric Administration (NOAA), 1982.

Contamination caused by HSL organics occurs at low levels, both in soil that was not formerly excavated and in reportedly clean soil that was backfilled into soil and drum excavations in 1974.

Because high levels of contamination were detected in the geologic strata below the backfill, it is concluded that the depth of soil excavation was too shallow. Contaminants tend to be concentrated in the thick clay horizon penetrated by one of the soil boring samples. Backfilled soil that exhibits contamination is interpreted to indicate one of the following:

- Slightly contaminated soil was used as backfill.
- Organic vapors volatilized from more highly concentrated soil underlying the backfill.
- The contamination has otherwise occurred following the backfilling.

Air monitoring during drilling indicates that contaminants concentrate in numerous thin clay zones. This conclusion is drawn from air monitoring of split-spoon samples containing thin clays in sand, and in boreholes which exhibit high borehole organic vapor readings, but zero or very low split-spoon readings and no HSL analytes.

Low levels of TVO and other HSL contaminants (base neutral compounds) appear to be dispersed in the subsurface in association with thin clay layers (less than 6 inches thick), zones of saturated limonitic sand, and other modes of occurrence of fine-grained particles. The predominant lithology, from depths of 6 feet to the water table, is the coarse to medium quartz sands of the Cohansey Formation which do not have a significant capacity to sorb the contaminants present at the site.

Groundwater

In the study area, groundwater flow direction in the water table aquifer is to the south and the groundwater flow gradient increases from the north to the south across the study area. Both of these factors may be attributed to an influence from the Tom's River Water Company wells.

A slight downward vertical gradient exists between wells screened in the Cohansey water bearing formation and the wells screened in the Kirkwood water bearing formation. A direct hydraulic connection exists between the Cohansey and Kirkwood water bearing formations. The average groundwater seepage velocity for the Cohansey water bearing formation was calculated to be 0.93 feet/day (340 feet/year).

Offsite Conditions

The 1974 Dover Township ordinance restricting groundwater use is still in effect and enforced. Based on the information obtained during this investigation contamination was detected in the groundwater in the vicinity of the Reich Farm Site. It can not be determined, however, that the Reich Farm Site is the source of this contamination. There is a potential for adverse health effects based on the risk assessment performed using the available analytical data for groundwater. All other calculated risks (direct contact with or inhalation of surface soil, etc.) indicate that the potential for health risks are minimal.

1.2.2 Potential Receptors

Potential receptors of site contaminants include employees or customers of adjacent businesses and casual intruders.

Contamination of groundwater may affect the population served by wells located downgradient of the site. Water use (primarily groundwater) in the vicinity of the site is predominantly for public and industrial water supply. In the vicinity of the site, a zone system was implemented to regulate the use of groundwater is flatly prohibited in Zone 1. Zone 2 (Figure 1-5) limits wells to the Kirkwood Formation. The Tom's River Water Company Well No. 20 is located approximately one mile south of the site, is screened in the Cohansey Sand, and has a depth of 87 feet. The Tom's River Water Company (TRWC) Parkway Wellfield is located 4,000 feet southeast of the site and has eight active wells screened in the Cohansey and Kirkwood Formations.

1.3 Present Remedial Investigation

The following Remedial Investigation field activities were conducted by IMS Engineers.

- June 1985 - Site reconnaissance and search of background information in the NJDEP, Ocean County Board of Health, and Dover Township files. Interviews with Dover Township and Ocean County officials, and private citizens connected with the 1971 dumping incident and the 1974 remedial response.
- June 1985 and April 1986 - Survey of existing off site wells as sampling locations.

- November 1985 - Performance of a magnetometer and ground penetrating radar survey by Weston Geophysical Corporation under IMS supervision. Establishment of the onsite sampling grid.
- April 1986 and May 1986 - Sampling of 7 residential and 5 municipal wells.
- May 1986 - Drilling and sampling of 25 soil borings providing 80 soil samples on site to characterize the vertical and horizontal extent of soil contamination.
- May 1986 through June 1986 - Drilling, installation, and testing of 10 monitoring wells and 1 observation well to determine subsurface conditions, to provide observation wells for a pumping test, and to provide groundwater sampling points.
- June 1986 - Sampling of 10 onsite monitoring wells; 1 offsite monitoring well; 4 municipal wells and 1 residential well; and resampling for inorganics only of 6 residential wells.

1.4 Overview of Report

Validated analytical results were not available for all samples; this report should, therefore, be considered a preliminary draft. The remaining sections of this report are described below:

Section 2.0, Geophysical Investigation, summarizes and further evaluates the magnetometer and ground penetrating radar survey performed by Weston Geophysical Corporation. A copy of Weston Geophysical Corporation's report is included as Appendix A.

Section 3.0, Soil Investigation, discusses the methods of the soil investigation, the extent and nature of contaminants in site soils.

Section 4.0, Hydrogeological Investigation, presents site-specific information on site geological and hydrogeological characteristics. Chemical analytical results for groundwater sampling is also included.

Section 5.0, Environmental Transport and Migration of Contaminants, provides information on the movement of site-related contaminants in the various media.

Section 6.0, Public Health and Environmental Concerns, discusses environmental and health risks associated with the site.

2.0 GEOPHYSICAL INVESTIGATION

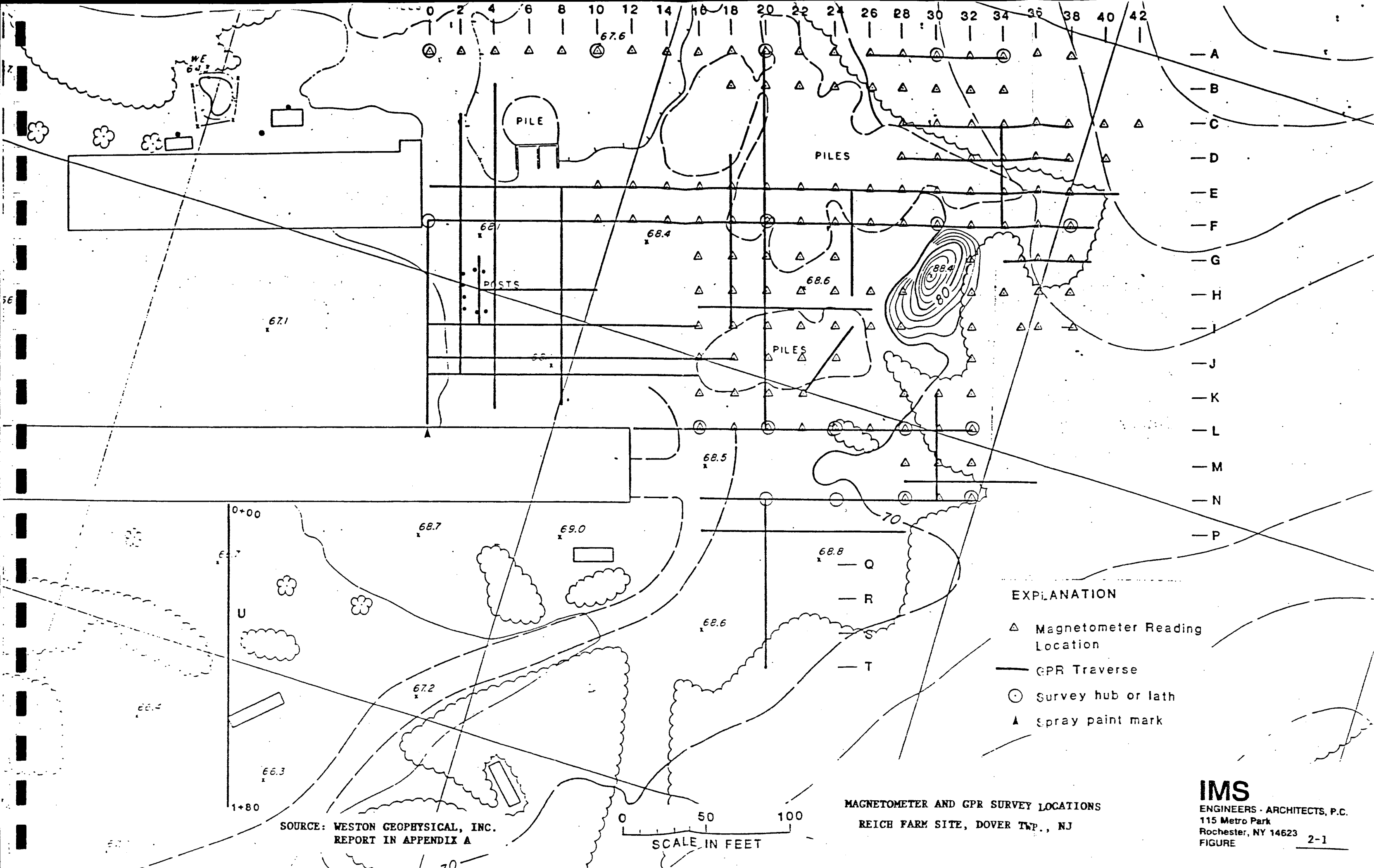
During the time period of November 21-23, 1985, Weston Geophysical and IMS Engineers performed a geophysical survey of the Reich Farm Site. The objective was to ascertain if containers of waste material remained buried at the site. Magnetometry in conjunction with ground-penetrating radar (GPR) techniques were utilized in the survey. The work included establishing a survey grid.

2.1 Methodology and Procedures

A complete discussion of the survey procedures is provided in Weston Geophysical Corporations' report in Appendix A. Both GPR and magnetometry surveys were performed along specified grid lines. The survey grid was established during the survey by Weston Geophysical and IMS personnel. It was not feasible to establish a permanent, staked grid prior to the survey, because of the constant commercial truck traffic on the site. During the survey the location of each GPR traverse line and each magnetometer reading was noted with respect to the perpendicular distance from the foundations of the L-Ed Construction Company building and the Toms River Heating Company building. Distances were measured by tape. Several permanent stakes were established in low traffic areas, which served as intermediary points. All survey traverses and survey points were made at multiples of twenty foot intervals from the buildings so that a grid location could be easily indexed. Figure 2-1 shows the survey grid, the location of GPR traverses and magnetometer reading points.

Due to the site commercial activity, it is anticipated that the permanent stakes will be lost. In order to locate soil borings or subsurface features in the future the grid will have to be reconstructed using the existing building foundations as perpendicular baselines. All numbered lines in Figure 2-1 are parallel with the east foundation of the L-Ed Company building. All lettered lines are parallel to the north foundation of the Toms River Heating Company building. All lines are twenty feet apart. Line O and Line L are coincident with the foundations.

A Geometrics model G-816 proton precession magnetometer with a sensitivity of ± 1 gamma was used for the magnetic survey. Measurements of the magnetic field were obtained at nodal points of the survey grid. The presence of large machinery, trailers, junk automobiles, and piles of construction materials limited the locations in which magnetic measurements could be taken. Figure 2-1 illustrates the data collection points. Diurnal variations in the magnetic field were



EXPLANATION

- △ Magnetometer Reading Location
- GPR Traverse
- Survey hub or lath
- ▲ spray paint mark

MAGNETOMETER AND GPR SURVEY LOCATIONS
REICH FARM SITE, DOVER TWP., NJ

monitored by taking magnetic field measurements at a designated reference station at 1 hour intervals.

Ground penetrating radar traverses were performed along specified grid lines using a 500 megahertz antenna. Physical obstructions and large areas of standing water following rain (inhibiting radar wave transmission) limited access over part of the site.

2.2 Results of the Geophysical Survey

A full discussion of the survey results can be found in Weston's report in Appendix A. The following will summarize the results and add additional observations or interpretations based on the soil borings discussed in Section 3.0.

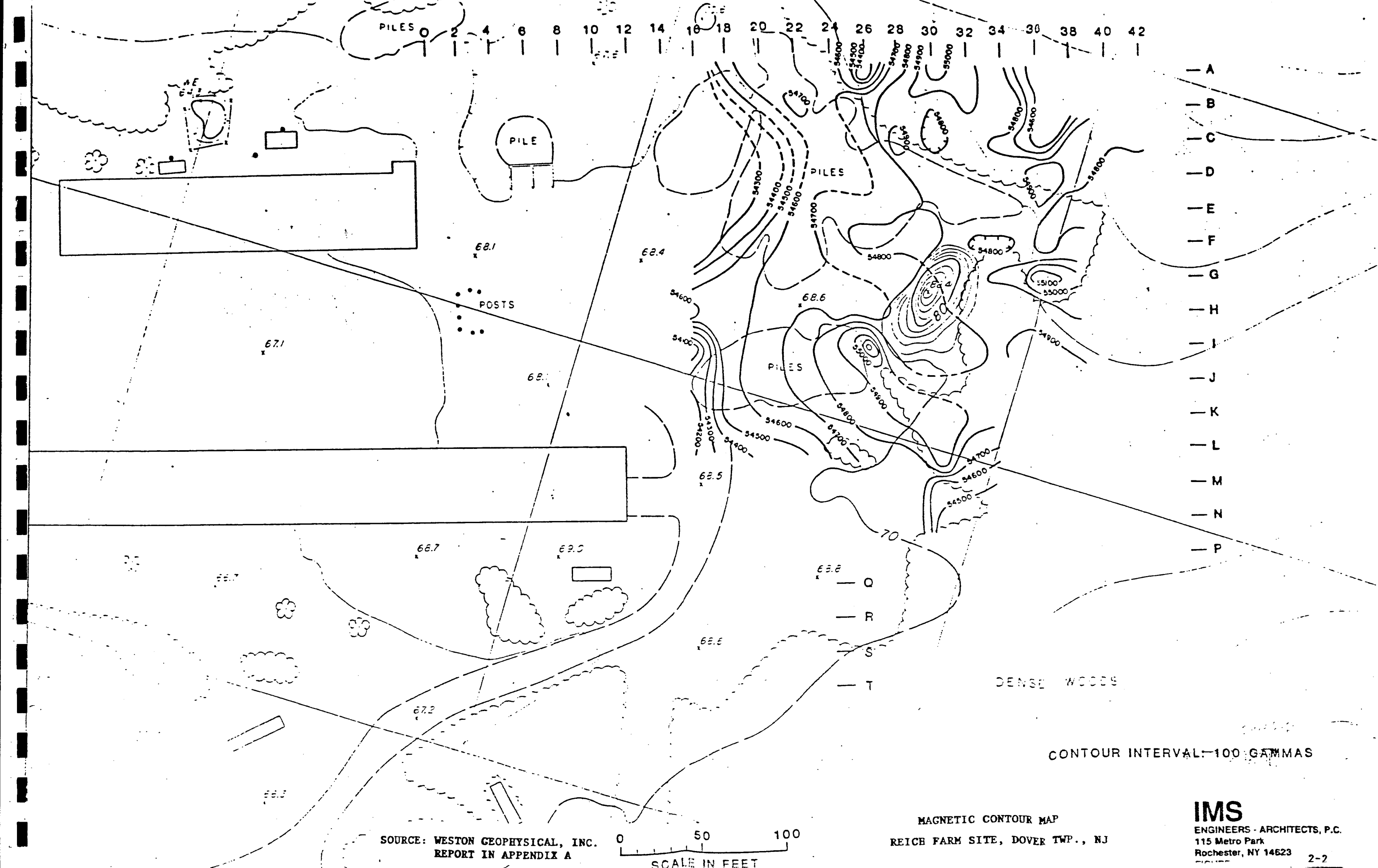
2.2.1 Magnetometer Results

A map of magnetic intensity contours at the Reich Farm Site is presented as Figure 2-2.

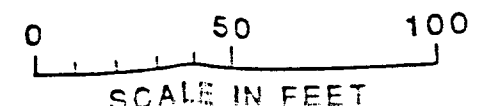
- A noticeable magnetic anomaly occurs at grid point I/26. Soil boring SB7 at I/27 intersected an unexplained subsurface cavity and very loose soil. Pieces of metal were retrieved by the lead auger. Buried material probably extends from I/26 to I/27.5, however, this material overlies an inferred trench, making it younger than the trench. The magnetic anomaly may be produced by shallow debris, buried after 1974.
- There is a noticeable absence of major magnetic anomalies, which would be characteristic of large numbers of drums buried in a trench.
- Other magnetic anomalies are explained by visible metallic objects on the site surface.

2.2.2 Ground Penetrating Radar Results

Figure 2-3 shows a map of radar reflections at the Reich Farm Site. A strong radar reflector occurs at a depth of approximately 6 feet under much of the site. See the Weston Report in Appendix A for GPR profiles that illustrate the several types of reflectors. Soil borings have demonstrated that this radar reflection coincides with a lithologic change from a sandy loam above 6 feet to undifferentiated stratified (Cohansey) sands below 6 feet.



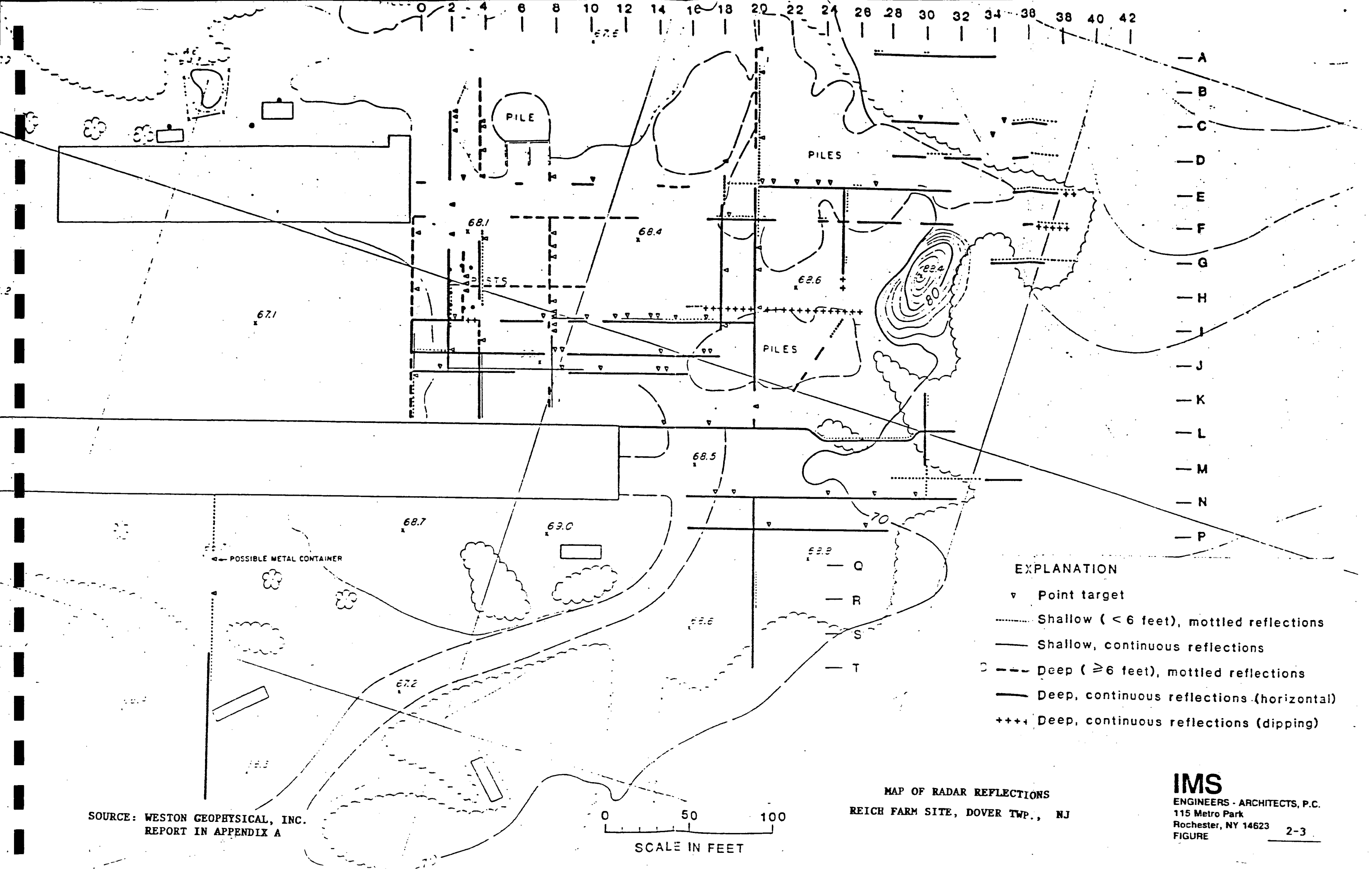
SOURCE: WESTON GEOPHYSICAL, INC.
REPORT IN APPENDIX A



MAGNETIC CONTOUR MAP
REICH FARM SITE, DOVER TWP., NJ

CONTOUR INTERVAL: 100 GAMMAS

IMS
ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
2-2



SOURCE: WESTON GEOPHYSICAL, INC.
REPORT IN APPENDIX A

0 50 100
SCALE IN FEET

MAP OF RADAR REFLECTIONS
REICH FARM SITE, DOVER TWP., NJ

IMS
ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE 2-3

The strong reflector is absent to the depth of radar penetration in several sharply defined areas. These areas are interpreted to be areas of excavation and backfill with a soil of uniform electrical properties.

In some areas the strong reflector degenerates into a mottled reflector. The interpretation of the mottled reflectors is uncertain, but the "mottling" may indicate variations in soil electrical properties due to contamination. This explanation is corroborated by the finding of organic vapors during drilling at SB9 (F/10) and SB16 (H/11) each in areas near mottled GPR reflectors.

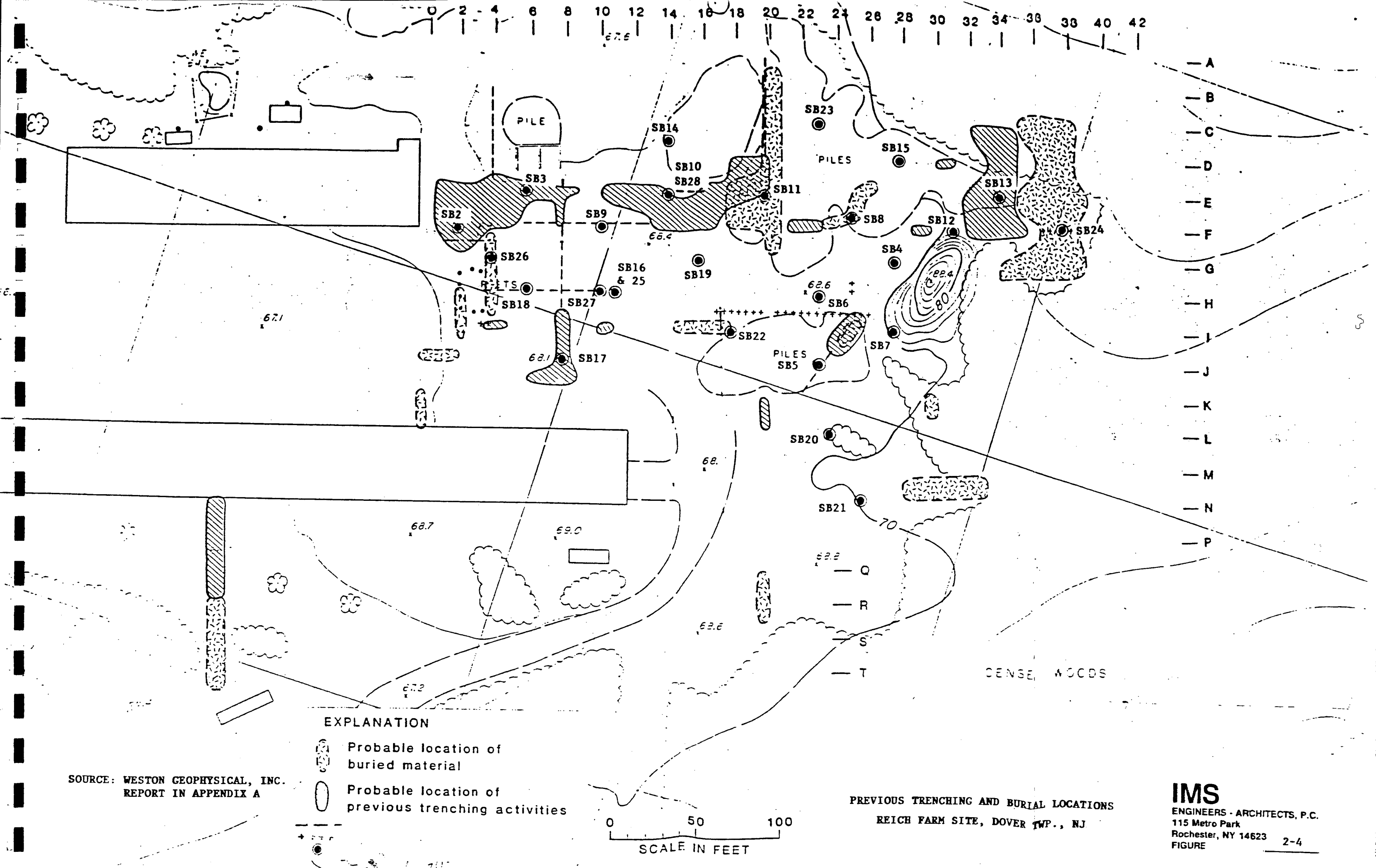
Approximately eighty shallow point targets or discrete objects were observed along the GPR traverses. These are generally at depths of less than four feet. The large number and widespread occurrence suggests that the point targets are due to the random burial of refuse derived from past commercial activities at the site, unrelated to hazardous waste. Weston's interpretation of the point target reflections is that the vast majority are not recognizable as drums. A set of point targets at I/17, however, may be drums.

Figure 2-4 shows several "locations of buried material." One possible explanation for these areas is that shallow burial was probably a convenient means used to dispose of refuse generated by (non-hazardous waste related) commercial activities on or around the site. For example, according to current tenants the feature at R/20 is a trench containing old metal chicken cages (the commercial buildings are former chicken coops) and at M/30 is a trench containing woodchips from a furniture refinisher. The shallow debris at line 20 overlies the adjacent trenched area, making it more recent; and the debris at line 38 is visible on the surface and consists of tree stumps and non-recyclable demolition debris. An area of buried debris overlies a trench at I/26, suggesting that the debris is younger than the trench at I/26, suggesting that the debris is younger than the trench and not related to the drum burial.

Numerous areas of shallow mottled reflections (shown as "Probable Location of buried material" in Figure 2-4 from the Weston Report) may be due to reflections from buried debris or from variations in electrical properties of the soil. One area with shallow SB26 (G/4), exhibited contamination in the upper 2 feet of soil.

The strong reflector exhibits a pronounced dip, between I/17 and I/26, which is interpreted to reflect varying electrical soil properties due to contamination by a conductive medium. Contamination was reported near or along line I at SB6 (H/23) and at SB7 (I/27).

Figure 2-4



SOURCE: WESTON GEOPHYSICAL, INC.
REPORT IN APPENDIX A

EXPLANATION

- Probable location of buried material
- Probable location of previous trenching activities

0 50 100
SCALE IN FEET

PREVIOUS TRENCHING AND BURIAL LOCATIONS
REICH FARM SITE, DOVER TWP., NJ

IMS
ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE 2-4

2.3 Conclusions

The geophysical techniques used at the Reich Farm demonstrated the absence of large quantities of buried waste containers. Two areas of concern at I/17 and I/26 were identified utilizing the GPR and magnetometer respectively. The decision to further investigate these two areas will need be made prior to the Feasibility Study.

Anomalous radar reflections in deep (greater than 6 feet), and shallow (less than 6 feet) zones appear to indicate soil contamination in certain areas, specifically between lines F and H near line 8, and at I/26.

Certain areas of the site were not able to be investigated by either GPR or the magnetometer. Site surface area beneath the crushing operation and beneath the storage trailers was not accessible.

Areas of previous trenching have been identified from the GPR survey.

3.0 SOIL INVESTIGATION

The objective of the soil investigation program was to determine the presence or absence of surface and subsurface soil contamination at the Reich Farm Site. Major tasks of the investigation were to

- Delineate areas of suspected contamination.
- Determine whether suspected areas are contaminated and, if so, define the vertical and horizontal extent of contamination.
- Identify and quantify the presence or absence of soil contaminants.
- Identify contaminant migration pathways from soil to groundwater and to air.

3.1 Characterization of Soils at the Reich Farm Site

The Reich Farm Site is underlain by the Downer sandy loam and loamy sand. Below the developed soil horizons are the undifferentiated sands of the Cohansey Formation. Downer soils occur on level to gently sloping areas where the contact between the Pennsauken Formation and underlying Cohansey Formations has been exposed to weathering processes. Downer soils range from 0 to 30 inches and encompass the entire site.

Downer soils have moderately high permeabilities throughout the soil profile. Abundant coarse rounded quartzose gravel is common and the soil is moderately to very strongly acid. Because of the comparatively low content of clay and organic matter, the Downer soils are considered to have only limited capacities for attenuating organic and inorganic priority pollutants.

The naturally occurring Downer soils have been either removed or modified over much of the site. A commercial cement contractor operates a crushing operation on the site. Approximately one-half of the site is used for access, trailer storage, and for the crushing operation. The remaining one half is used to store demolition debris (cement, asphalt, bricks, stone) on the site surface prior to and following the crushing operation. As a result foreign materials are being continuously moved onto and removed from the site surface. Because of truck and heavy machinery traffic, the upper portion of the surface soils are heavily compacted, which reduces the soil permeability to some degree.

3.2 Technical Approach

The technical approach to the soil investigation program was to evaluate the effectiveness of the contaminated soil and drum excavation program conducted by Dover Township in 1974. Objectives of the 1974 program were to remove obviously contaminated soil and secondly to search for and remove buried waste. Records documenting details of the soil and drum removal are not presently in Dover Township files and are presumably no longer in existence. It is known, however, that no analytical testing was conducted to verify the extent or nature of soil contamination prior to or following excavation.

Areas of drum staging and drum (or other waste container) burial were determined for this project by personal interviews of township officials and contractors who were involved in the soil and drum removal. Soils underlying and peripheral to areas of prior excavation were targeted as biased sampling locations. Twenty-five soil borings were divided between biased locations determined from background information or from ongoing data review in the field, and other randomly chosen locations.

The ground penetrating radar (GPR) survey identified the subsurface zones in which naturally occurring soil horizons are disturbed below a depth of 6 feet. These zones are presumed to have been areas of soil excavation (trenching) and backfilling. Since drums were not detected in the backfilled trenches, it is assumed these areas were excavated by Dover Township workers in 1974. The minimum necessary depth of sampling was considered to extend below the depth of the 1974 excavations which had been reportedly backfilled with clean soil down to 16 feet. The maximum depth of trenches identified by soil borings was 11 feet.

3.2.1 Methodology and Procedures

Twenty-five boreholes were drilled with a hollow-stem auger and sampled with a 2-inch split-barrel sampler using the standard penetration test. Three near surface (0-2 feet) samples were obtained by driving the samples from the surface. A total of 80 eight samples was collected. Sampling depths were commonly 5, 10, and 15 feet. In areas where prior soil excavation was evident, sampling was extended to depths at which undisturbed geologic strata could be observed.

Each borehole and split-spoon sample was monitored with a HNU organic vapor meter during drilling and sampling. Several previously planned boring locations were changed in the field as a pattern of soil contamination became apparent from the HNU data. In addition, the sampling

depths were varied depending upon the detection of organic vapors during drilling. For example, boring SB3 was sampled at 5 feet, 7.5 feet, and 12.5 feet, because of high HNU readings at 5 to 7 feet.

Augers were decontaminated between holes and sampling equipment was decontaminated between samples.

Soil samples were shipped in prewashed glass jars obtained through the USEPA Bottle Repository Program. Analytical work was performed through the EPA Contract Laboratory Program. The following analyses were conducted:

- HSL Volatile Organics
- HSL Semi-volatile Organics
- HSL Pesticides and PCBs
- HSL Inorganics
- Total Organic Carbon
- Oil and Grease
- Petroleum Hydrocarbons

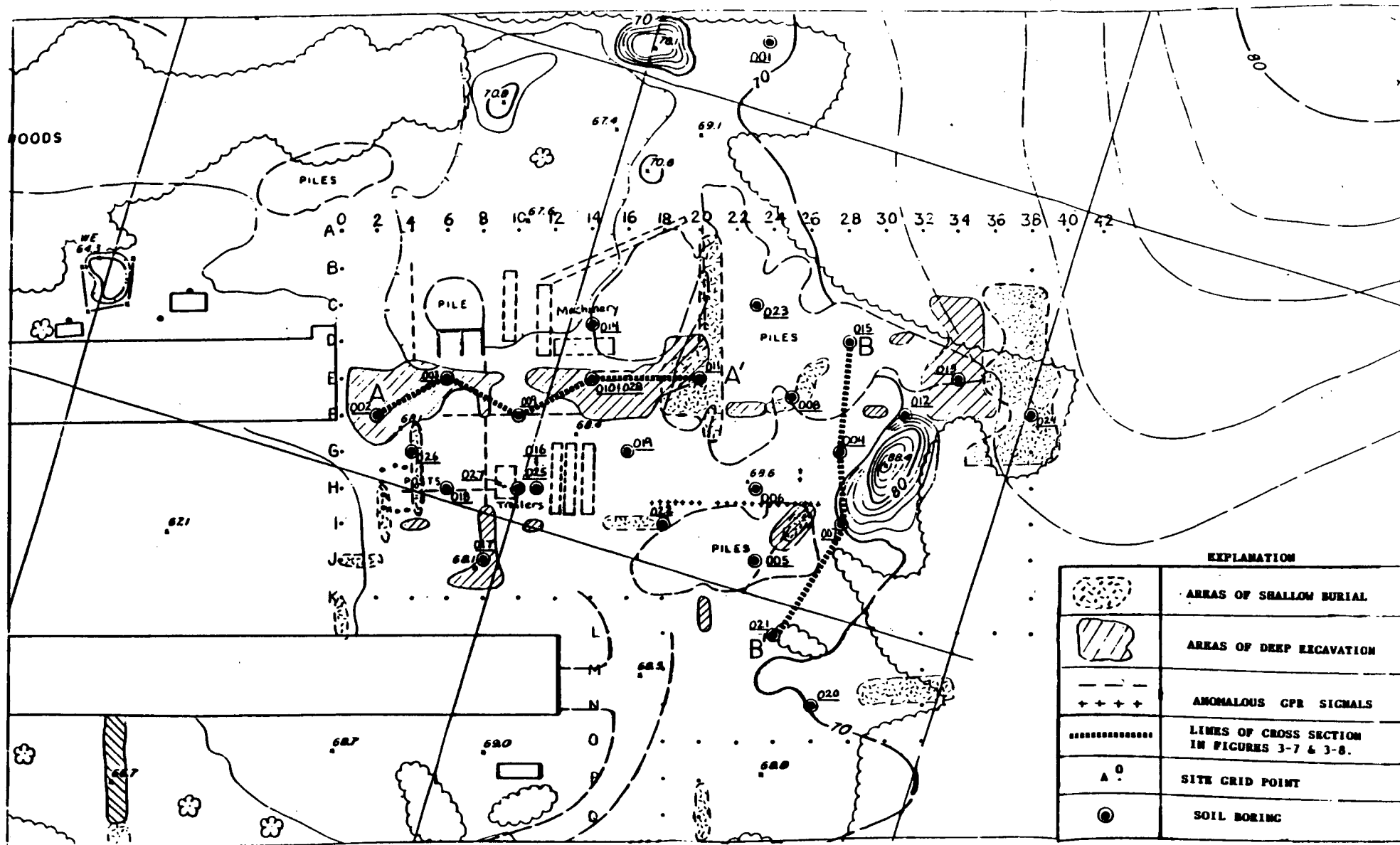
3.2.2 Boring Locations

All samples were located with respect to the site grid that was established during the geophysical survey. The extent of the grid was defined on the basis of personal interviews and a 1972 aerial photograph showing the former tree lines and nonvegetated areas. Figure 3-1 shows the site grid, the boring locations, and areas of excavations as determined from the GPR survey.

The geophysically determined features that guided the choice of soil boring locations include

- The magnetic anomaly at I/26.
- Areas of deep trenches.
- Areas of shallow buried material.
- Dipping radar reflectors.
- Mottled radar reflectors.

Figure 3-1 illustrates each feature and shows the soil boring that was located (as near as practical) to each.



EXPLANATION	
	AREAS OF SHALLOW BURIAL
	AREAS OF DEEP EXCAVATION
	ANOMALOUS GPR SIGNALS
	LINE OF CROSS SECTION IN FIGURES 3-7 & 3-8.
	SITE GRID POINT
	SOIL BORING

SOURCE: GEOPHYSICAL FEATURES ARE
TAKEN FROM WESTON GEOPHYSICAL,
INC. REPORT

SOIL BORING PLAN, GEOPHYSICALLY
DETERMINED FEATURES, AND CROSS-SECTION LINES
REICH FARM SITE, DOVER TWP., NJ

IMS
ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE 3-1

Borings SB1 through SB11 were biased locations based on background information. Specifically, SB1 was the background boring. The area of SB2, SB3, SB9, SB10, and SB11 was reportedly the staging area for the drums. Drum burial reportedly occurred in the vicinity of SB5, SB6, SB7, and SB8. Borings SB17, SB13, and SB24 were located to investigate areas of trenching or shallow burial based on the GPR survey. SB22 was located near a group of buried GPR targets, which could be drums. SB9, SB16, SB18, SB5, and SB6 were located near areas of anomalous GPR reflections. All remaining boring locations were chosen in the field on the basis of site access and of having positions peripheral to a developing pattern of air monitoring data.

3.3 Stratigraphy of Shallow Soils

Boring logs were prepared for each borehole. The objectives were to

- More fully describe subsurface features observed in the GPR survey.
- Describe the shallow stratigraphy.
- Correlate contamination with soil type.

Boring logs for each borehole are presented in Appendix B.

The GPR survey revealed a prominent reflector at depths of 5 to 6 feet beneath the site. Split-barrel sampling between 5 to 7 feet revealed a contact between a dark brown, gravelly, loamy sand overlying medium to coarse sands of the Cohansey. The overlying loam rarely exhibits stratification, whereas stratification in the underlying sands is distinctive. Above the water table highly oxidized Cohansey sediments exhibit thin beds of sharply contrasting colors; yellow brown, light brown, deep red, orange and grey white. Beds of well sorted medium sands containing cross bedded heavy mineral laminae are common. Clay also occurs in the sand as small spherical aggregates with a sandy matrix and as localized clumps adjacent to pebbles. Thin, saturated layers of red limonitic sand are also common.

Based on the GPR results, soil disturbances at a depth of 10 feet were predicted at borings SB3, SB7, SB13, and SB17. Soil sampling showed evidence of soil excavations to 10 to 11 feet in borings SB3, SB4, SB6, SB7, SB10, SB13, and SB17. The soil contact is present at SB2 and SB11, where deep mottled GPR reflections were observed.

Zones of disturbed (e.g., backfilled) soil exhibited above-background organic vapor readings in SB3, SB4, and SB6. Hence, either these areas were backfilled with somewhat contaminated soil or the soil was contaminated at a later date. The loam/sand contact occurs at 2 feet in borings SB11, SB15, SB18, and SB23. This is the natural solum thickness. In all remaining borings, the soil is disturbed from the surface to 5 to 6 feet.

A discontinuous clay bed underlies a portion of the site. The top of the clay occurs at 15 to 17 feet in borings SB1, SB4, SB6, and SB7. It also occurs at monitoring well MW1 where it is 8 feet thick. The clay is absent in all other borings, including SB13, SB21, and SB25, which were sampled from 18 to 20 feet or deeper. Where present, the clay may produce a temporary perched water table. However, this was not evident at the time of sampling. In addition, the clay may attenuate the downward infiltration of contaminants. The clay's attenuation capacity may explain the high contaminant concentrations observed in SB4. The inferred boundary of the clay bed is shown on Figure 3-2.

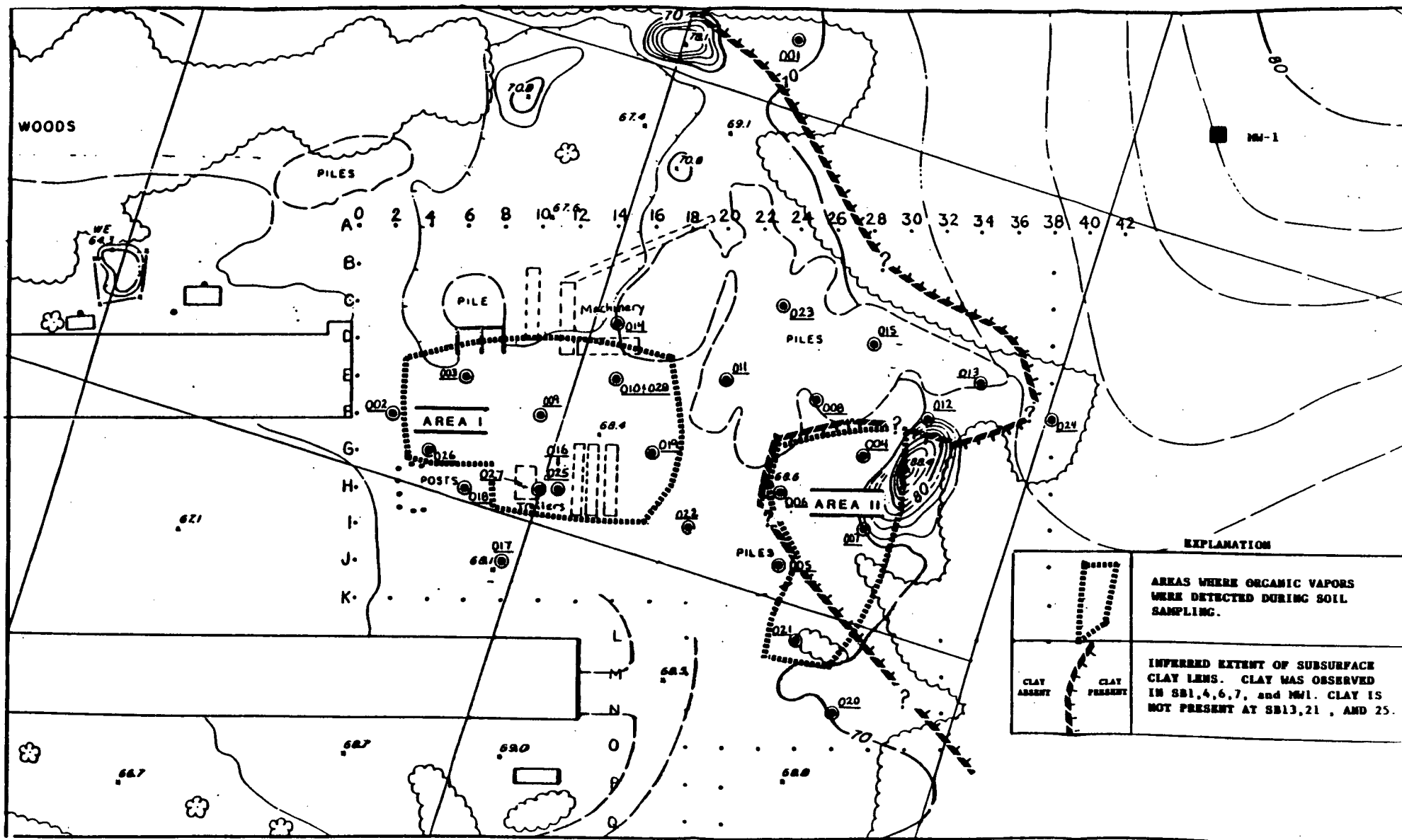
3.4 Air Monitoring Results

Organic vapor measurements were obtained with an HNU from the following points during soil sampling:

- Soil on the auger flights.
- Inside the hollow auger.
- Inside the split spoon.
- Inside the sample mixing beaker.

The organic vapor data revealed qualitative information on the pattern of soil contamination present at the Reich Farm Site. Organic vapor measurements are noted on the soil boring logs in Appendix B.

Two areas of the site exhibited above-background organic vapor measurements. Figure 3-2 shows the inferred limits of each area. Area I, with borings SB3, SB9, SB10, SB16, and SB25, is located near the Le-Ed Co. building and occupies the reported 1971 drum staging area. Area II, with borings SB4, SB6, SB7, and SB21, is located along the east tree line and occupies the reported drum excavation/burial area. The nature of readings from a single boring suggests that soil contamination is confined to discrete layers, probably rather thin, which have the capacity to sorb volatile organic contaminants. The following observations were made:



GENERALIZED EXTENT OF SUBSURFACE
ORGANIC VAPORS; AND OF SUBSURFACE CLAY.
KETCH FARM SITE, DOVER TWP., NJ

- In a split-spoon, layered samples exhibited organic vapors (where present) in clay rich zones or in thin layers of saturated limonitic sand; whereas the clean quartz sand exhibited no organic vapors.
- Organic vapors were often detected in the soil on auger flights, but not in the split-barrel sample.
- Organic vapor levels in the hollow auger reached 100 to 300 ppm, while readings at the auger flights and in the split-spoon were less than 50 ppm and generally less than 10 ppm. High organic vapor levels (above 100 ppm) persisted for only limited depth intervals (e.g., 1 to 2 feet). Extreme readings may have resulted from the rapid volatilization of sorbed organics due to contact with the hot auger bit.
- Discrepancies between field monitoring and analytical results occurred for borings SB25/16 and SB21. For example, readings in the auger ranged from 2 to 3 ppm at 19 feet to 300 ppm at 20 feet in SB25. The sample obtained from 20 to 22 feet demonstrated no HSL constituents above the detection limit. One explanation of this phenomenon is that a thin contaminated layer occurs between 19 feet and 20 feet but was not sampled. Instrumental behavior was stable; calibration was checked; and readings were reproducible. Similarly, HNU readings of 175 ppm occurred at 10 feet depth in SB21, but all HSL analytical results were negative.

Air monitoring results indicate a potential for the release of organic vapors during any remedial action involving soil excavation. No organic vapors were detected using the HNU organic vapor meter in areas of undisturbed soil. Organic vapors were detected between the surface and a depth of 5 feet in only four boreholes: SB4, SB9, SB10, and SB14.

3.5 Analytical Results

Tables 3-1 and 3-2 present summaries of organic and inorganic analytical results, respectively, for surface and subsurface soil samples from the Reich Farm Site. Detections, concentration ranges, and concentration averages are presented.

TABLE 3-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN SITE SOILS
REICH FARM SITE

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Volatiles (µg/kg)</u>						
acetone	18/74	170	5-12,000	3/5	8	9-17
2-butanone	16/74	832	3-31,000	4/5	7.4	8-11
4-methyl-2-pentanone	4/74	1.3	5-47	--	--	--
2-hexanone	3/74	1.2	10-45	--	--	--
carbon tetrachloride	--	--	--	--	--	--
1,1-dichloroethane	--	--	--	--	--	--
methylene chloride	3/74	18	15-1,300	--	--	--
tetrachloroethene	4/74	76	1-5,500	4/5	8	1-22
1,1,1-trichloroethane	2/74	0.3	3-17	1/5	1	7
trichloroethene	5/74	0.01	1	--	--	--
trans-1,2-dichloroethene	--	--	--	1/5	0.2	1
chloroform	--	--	--	--	--	--
toluene	14/74	13	1-810	3/5	25	8-99
ethylbenzene	7/74	120	3-6,100	3/5	18	2-59
styrene	3/74	1,247	250-68,000	--	--	--
total xylenes	8/74	29	2-1,600	3/5	55	26-180
benzene	--	--	--	--	--	--
chlorobenzene	3/74	1	6-27	2/5	34	68-100
bromoform	--	--	--	--	--	--
vinyl acetate	1/74	0.1	1	--	--	--
<u>Acid Extractables (µg/kg)</u>						
phenol	1/74	90.5	6,700	--	--	--
pentachlorophenol	--	--	--	--	--	--
2,4-dichlorophenol	--	--	--	--	--	--
4-chloro-3-methylphenol	--	--	--	--	--	--

TABLE 3-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN SITE SOILS
REICH FARM SITE
PAGE TWO

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Base/Neutral Extractables</u> ($\mu\text{g/kg}$)						
bis(2-ethylhexyl)phthalate	17/74	2,403	37-160,000	5/5	2,448	400-5,700
di-n-octyl phthalate	3/74	29	67-1,900	1/5	114	570
di-n-butyl phthalate	10/74	11	34-240	4/5	53	71-110
diethyl phthalate	1/74	0.2	17	--	--	--
butylbenzyl phthalate	2/74	72	1,000-4,300	2/5	154	350-420
benzo(k)fluoranthene	--	--	--	--	--	--
benzo(a)anthracene	1/74	0.5	34	--	--	--
fluoranthene	1/74	0.5	37	1/5	36	180
pyrene	2/74	1	37	1/5	22	110
2-chloronaphthalene	--	--	--	--	--	--
isophorone	--	--	--	--	--	--
1,2-dichlorobenzene	2/74	7	220-310	--	--	--
<u>Pesticides/PCBs</u> ($\mu\text{g/kg}$)						
BHC	20/74	5.3	1.6-100	--	--	--
heptachlor epoxide	2/74	0.3	1.5-24	--	--	--
heptachlor	1/74	0.02	1.4	--	--	--
endrin	3/74	0.4	8.85	--	--	--
aldrin	2/74	0.05	2.6	1/5	1	7.2
dieldrin	1/74	0.05	3.6	--	--	--
endosulfan I	1/74	0.02	1.4	--	--	--
chlordane	1/74	0.5	38	--	--	--
4,4'-DDE	3/74	0.2	9	--	--	--
4,4'-DDD	1/74	0.05	3.7	--	--	--
aroclor-1242	1/74	3	210	--	--	--
aroclor-1248	1/74	7	510	--	--	--

Notes: (--) -Indicates compound not detected above detection limits.

TABLE 3-2
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN SITE SOILS
REICH FARM SITE

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Inorganics (mg/kg)</u>						
aluminum	80/80	1,312	23-4,478	5/5	3,742	3,149-4,262
barium	80/80	7	1-80	5/5	12	9-16
beryllium	59/80	0.2	0.1-0.4	3/5	0.06	0.1
cadmium	--	--	--	--	--	--
calcium	77/80	1,191	17-28,250	5/5	884	403-1,850
chromium	78/80	7	1-46	5/5	4.2	2-6
cobalt	77/80	1.2	1-11	5/5	1.4	1-2
copper	62/80	2.6	1-23	5/5	5.2	6-20
iron	79/80	3,005	16-14,636	5/5	4,364	3,797-5,062
lead	26/80	3.1	3-61	5/5	11.2	6.9-15
magnesium	76/80	349	10-8,757	5/5	212	152-241
manganese	78/80	10	1-35	5/5	15.6	9-31
mercury	9/80	0.03	0.1-0.6	--	--	--
nickel	1/80	0.3	21	--	--	--
potassium	48/80	821	357-4,452	--	--	--
selenium	--	--	--	--	--	--
silver	37/80	1.8	2.1-7.0	--	--	--
sodium	52/80	464	12-9,313	2/5	206	506-526
tin	--	--	--	--	--	--
vanadium	75/80	8.0	1.1-33.4	5/5	6.0	4.7-7.6
zinc	67/80	6.0	1-44	5/5	8.4	2-17

Notes: (--) - Indicates compound not detected above detection limits.

Volatile, semi-volatile, and pesticide/PCB organic contamination were detected. Volatile organic contamination detected includes halogenated aliphatic hydrocarbons, aromatic hydrocarbons, and ketones. Semi-volatile organics detected include phthalate esters, polynuclear aromatic hydrocarbons (PAHs), 1,2-dichlorobenzene, and phenol. Two PCBs and eleven pesticides were found. Figure 3-3 presents the organic soil contamination detected in each boring and the depth at which contaminants were detected.

Most of the organic contamination detected is consistent with the general waste descriptions provided by Union Carbide Corporation (e.g., "lab waste solvents," "blend of resin and oil," "solvent washes of process equipment"). However, the widespread, low-level detection of various pesticides (see Table 3-1) is not indicative of the site's waste disposal history, but is more likely to be associated with the past agricultural use of this and surrounding lands. Additionally, the PCB and PAH detections occurred infrequently and appear to be anomalous.

Available information on the history of waste disposal at the site does not suggest a potential inorganics contamination problem. In corroboration, metals and trace elements detected in soil samples were generally not present above naturally-occurring levels. Table 3-3 presents a comparison of the inorganics ranges detected in site soils with those reported as natural by Shacklette and Boerngen (1984).

As can be seen from Figure 3-3, the most prevalent soil contaminants in terms of frequency of detection and concentration, are monocyclic aromatics, ketones, and phthalate esters. Monocyclic aromatics detected include toluene, ethylbenzene, chlorobenzene, styrene, phenol, and xylenes. Ketones detected include acetone, 2-butanone (methylethylketone), 4-methyl-2-pentanone (methylisobutylketone), and 2-hexanone. Phthalate esters detected include bis(2-ethylhexyl)phthalate, di-n-octylphthalate, di-n-butylphthalate, diethylphthalate, and butylbenzylphthalate.

Soil contamination is the most evident at soil borings three and four (SB3 and SB4). These borings are located on opposite ends of the site; SB3 in the western portion in the former drum staging area (Area I), and SB4 in the eastern portion in the former trench area (Area II). Maximum concentrations of 4-methyl-2-pentanone, phenol, toluene, xylenes, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate occurs at SB3. The total volatile organics (TVO) concentration in samples collected from SB3 was 3,130 µg/kg. Maximum concentrations of acetone, 2-butanone, methylene chloride, tetrachloroethene, ethylbenzene, and styrene occur at SB4. The TVO here was

Figure 3-3

TABLE 3-3
SOIL INORGANICS RANGES ON THE REICH FARM SITE
COMPARED TO THE EASTERN U.S. (SCKLETTE & BOERNGEN, 1984)

	Site Soil Concentration Range (mg/kg)	Observed Range (mg/kg) (Eastern U.S.)
aluminum	23-4,478	7,000-> 100,000
barium	1-80	10-1,500
beryllium	0.001-0.4	< 1-7
cadmium	ND	NR
calcium	17-28,250	100-280,000
chromium	1-46	1-1,000
cobalt	1-11	< 0.3-70
copper	1-23	< 1-700
iron	16-14,636	< 100-> 100,000
lead	3-61	< 10-300
magnesium	10-8,757	50-50,000
manganese	1-35	< 2-7,000
mercury	0.1-0.6	< 0.01-2.0
nickel	21	< 5-700
potassium	357-4,452	50-37,000
selenium	ND	< 0.1-3.9
silver	2.1-7.0	NR
sodium	12-9,313	500-50,000
tin	ND	< 0.1-10
vanadium	1.1-33.4	< 7-300
zinc	1-44	< 5-2,900

ND - Not Detected

NR - Not Reported

180,765 $\mu\text{g/kg}$, making this the most contaminated area sampled. These two borings are representative of the areal contaminant distribution. Other borings in each of these areas are the next most highly contaminated, in terms of TVO, though none compare with concentrations in SB3 and SB4. In the former drum staging area, SB9, 10, and 18 exhibited TVO concentrations of 144 $\mu\text{g/kg}$, 507 $\mu\text{g/kg}$, and 270 $\mu\text{g/kg}$, respectively. In the former trench area, SB6 and 13 exhibited TVO concentrations of 140 $\mu\text{g/kg}$ and 238 $\mu\text{g/kg}$, respectively.

The GPR survey data and the boring logs indicate that the soil in the area of SB3 was excavated to a depth of approximately 10 feet and was backfilled during the initial site remedial measures taken during 1974. The chemical analytical data indicate that the contamination is greatest in the sample collected from below this depth and corroborates this hypothesis. However, the data also indicates that the supposed fill material is also contaminated. The mechanism by which this material was contaminated can only be hypothesized.

The boring log indicates that SB4 is located in a previously excavated area. A thick clay observed in MW1 is likely to underlie SB4 beginning at a depth of 16 to 17 feet. A sample collected from a depth of 10 to 12 feet, at the interface of the fill material and the natural soil, demonstrated the highest level of organic contamination detected in any soil sample (117,000 TVO). A sample collected at the top of the clay layer also demonstrated significant contamination (63,000 TVO). This clay may be impeding the percolation of water and thus the migration of the chemicals from this area. This clay was also encountered in SB7, located approximately 25 feet from SB4, but little organic contamination was detected in samples collected from this boring.

Surface soil sampling was limited to three locations on the site. All three locations are in the former drum storage area (Area 1) of the site (SB26, SB27, and SB28). As can be seen on Figure 3-3, several volatile organics and a few phthalate esters were detected at each surface sample location. Total volatile organic (TVO) concentrations at SB26, 27, and 28 are 69 $\mu\text{g/kg}$, 54 $\mu\text{g/kg}$, and 457 $\mu\text{g/kg}$, respectively. Based on these results, organic contamination may be present over much of the surface area of the former drum staging area.

Conclusions

Contamination caused by HSL organics occurs at low levels, both in soil that was not formerly excavated (in SB3, SB10, SB4, and SB6) and in reportedly clean soil that was backfilled into soil and drum excavations in 1974.

Because high levels of contamination are present in geologic strata (below the backfill in SB3 and SB4), it is concluded that the depth of soil excavation was too shallow. Contaminants tend to be concentrated in the thick clay horizon penetrated in SB4. Backfilled soil that exhibits contamination is interpreted to indicate one of the following:

- Slightly contaminated soil was used as backfill.
- Organic vapors volatilized from more highly concentrated soil underlying the backfill.
- The contamination has otherwise occurred following the backfilling.

The downward decrease in TVO (comprised of aromatic hydrocarbons) in SB10 may be due to a fuel spill occurring since 1974.

The downward increase in TVO in SB3 and SB4 indicates an inadequate depth of soil excavation in 1974.

Air monitoring during drilling indicates that contaminants concentrate in numerous thin clay zones. This conclusion is drawn from air monitoring of split-spoon samples containing thin clays in sand, and in boreholes which exhibit high borehole organic vapor readings, but zero or very low split-spoon readings and no HSL analytes.

Low levels of TVO and other HSL contaminants (base neutral compounds) appear to be dispersed in the subsurface in association with thin clay layers (less than 6 inches thick), zones of saturated limonitic sand, and other modes of occurrence of fine-grained particles. The predominant lithology, from depths of 6 feet to the water table, is the coarse to medium quartz sands of the Cohansey Formation which do not have a significant capacity to sorb the contaminants present at the site.

4.0 HYDROGEOLOGIC INVESTIGATION

4.1 Objectives

The objectives of the hydrogeologic investigation at the Reich Farm site were:

- To determine if groundwater contamination exists in the uppermost aquifer beneath the site.
- To determine if a groundwater contaminant plume is present beneath the site. If present, the objective was to define the extent of the contaminant plume.
- To characterize subsurface lithology beneath, and adjacent to, the site property.
- To establish groundwater quality.
- To determine groundwater flow direction and velocity.
- To provide data points for aquifer testing in order to determine aquifer parameters.
- To generate adequate data for the recommendation of remedial measures.

4.2 Description of Field Activities

The hydrogeologic field investigation consisted of monitoring well drilling and installation, water level measurements in monitoring wells, borehole geophysics and aquifer testing. In addition information from the soil and surficial geophysical investigation was incorporated in to the hydrogeologic investigation.

Drilling Operations

A total of 10 monitoring wells MW-1 through MW-10 and one observation well OW-1 were installed during the investigation. The locations of all monitoring wells are shown in Figure 4-1. All monitoring wells and the observation well, except MW-2 and MW-7, were placed into the Cohansey Formation. Monitoring wells MW-1 and MW-7 were installed into the Kirkwood Formation. Two

pairs of cluster wells were installed at the site. They are at well cluster locations MW-1/MW-2 and MW-7/MW-8. The purpose of these well clusters was to define the water level elevations in the water-bearing formations and their interconnection. Monitoring wells MW-1 and MW-7 were terminated at the depth of 175 and 190 feet below the ground surface respectively. The remaining eight monitoring wells were installed to depths ranging from 40 to 80 feet below the surface. Observation well MW-1 was drilled in the vicinity of monitoring well MW-3 to provide an observation point during a planned pumping test in well MW-3. All boreholes were advanced using mud rotary drilling techniques with bentonite drilling mud. An 8-inch diameter hollow drilling bit was used to advance the borehole. Formation samples were taken at desired locations and depths using standard split-barrel sampling techniques with a 5-foot sampling interval most commonly used. All drilling equipment was decontaminated with pressured steam prior to drilling each borehole.

Formation samples obtained during drilling operations were lithologically logged by the field geologist and stored for future reference. Split-barrel samples were described using the Unified Soil Classification System and stored in sealed glass jars. Logs for each of the borings are provided in Appendix C-1.

Monitoring Well Construction

All monitoring wells were constructed in a minimum 8-inch diameter boring. After the boring was drilled, potable water was circulated down the hole to decrease the drilling mud viscosity. This procedure promoted a more rapid development. Either 10 or 20 feet of 0.010 slot, 4-inch diameter, stainless steel wire wound well screen was installed to the desired depth. Flush joint, threaded 4 inch diameter, stainless steel casing was installed from the top of the well screen to 2 feet above the ground surfaces. Number one sand was emplaced from the bottom of the hole to at least two feet above the top of the well screen, where a bentonite-pellet seal at least 5 feet thick was installed. The remaining annulus was filled with a cement-bentonite slurry.

An 8-inch diameter, 5-foot long protective steel casing with a hinged or screwed, locking cap was installed over each well. The protective casing was installed to a minimum of 3 feet into the annulus of each borehole. The annulus was then filled to the ground surface with cement and an anti-percolation collar constructed around the base of the casing.

Observation well OW-1 was constructed of 1 1/2 inch diameter PVC riser pipe and ten feet long, slotted PVC well screen. The annulus of the borehole was backfilled with number one sand to above

the top of the well screen. The remainder of the borehole was backfilled with drill cuttings to the ground surface. Since the well was to be used for water level readings only, a protective casing was not placed around the riser pipe.

A well construction log for each well is shown in Appendix C-2. A summary of well construction is shown in Table 4-1.

Well Development

Each monitoring well was developed by the compressed airlift method. Wells MW5 and MW8 were further developed by pumping. In the compressed airlift method a 3/4 inch diameter air line was lowered down into the well. The compressed air was intermittently turned on and off causing the water in the well to rise up the casing and fall back down. Compressed air was also allowed to run continuously to remove suspended particles from the well. In MW5 and MW8 the static head was too low for air lifting to operate effectively; consequently, each well was pumped for approximately two hours with a submersible pump. Development was deemed complete when the discharge water became visibly clear of sediment; however, well MW1 was developed by air lifting for 5 1/4 hours, without a progressive clearing of the water.

Water Level Measurements

Water levels were measured in monitoring wells, periodically throughout the performance of field activities. Measurements were taken with an M-Scope (electrical water level indicator), popper, or steel measuring tape, using the top of the well casing or top of the staff gauge as the reference point for determining depths to water. Complete sets of water level measurements were taken on six different days from all wells (Table 4-2). These water levels were used to determine groundwater flow directions in the study area. A discussion of groundwater flow directions is provided in Section 4.6.

Borehole Geophysical Logging

Geophysical logging of monitoring wells MW-1 and MW-7 was performed as part of the study. The suite of logs run included natural gamma, resistivity, and spontaneous potential logs. Any interpretation of the logs was used to supplement information gathered during drilling and aquifer testing operations. The geophysical logs are shown in Appendix C-3.

TABLE 4-1
SUMMARY OF WELL CONSTRUCTION AT THE
REICH FARM SITE

Well No.	Ground Elevation (Ft. MSL)	Screen Depth (Ft)		Screen Elevation (Ft. MSL)		Total Depth (Ft)
		Top	Bottom	Top	Bottom	
MW-1	74.10	115	125	-41.24	-51.24	175
MW-2	74.10	45	55	28.66	18.66	57
MW-3	68.80	35	55	33.50	13.50	57
MW-4	66.70	35	55	31.74	11.74	85
MW-5	68.30	30	40	38.47	28.47	42
MW-6	68.30	30	50	37.46	17.46	55
MW-7	72.50	110	120	-37.88	-47.88	190
MW-8	73.00	40	50	32.62	22.62	52
MW-9	64.40	60	80	4.56	-15.44	90
MW-10	72.80	60	80	12.33	-7.67	95
OW-1	68.60	40	50	28.47	18.47	52

TABLE 4-2

**WATER LEVEL ELEVATIONS IN MONITORING WELLS
REICH FARM SITE
DOVER TOWNSHIP, NEW JERSEY**

Well No.	Elevation of Measuring Point	05/23/86 Elevation	05/27/86 Elevation	05/29/86 Elevation	05/30/86 Elevation	06/02/86 Elevation	06/03/86 Elevation	06/05/86 Elevation	06/06/86 Elevation	06/09/86 Elevation	06/10/86 Elevation	06/11/86 Elevation
MW-1	75.76'	34.00'	37.31'	37.29'	38.21'	38.21'	38.17'	38.21'	38.25'	38.12'	38.21'	38.17'
MW-2	75.66'	---	38.96'	38.27'	38.23'	38.19'	38.17'	38.19'	38.21'	38.11'	38.32'	38.25'
MW-3	70.50'	---	---	---	37.20'	37.03'	36.99'	37.05'	37.11'	37.03'	37.03'	37.03'
MW-4	68.74'	---	---	---	36.81'	36.90'	36.85'	36.81'	36.79'	36.75'	36.90'	36.81'
MW-5	70.47'	---	---	---	38.50'	37.42'	37.40'	37.42'	37.42'	37.38'	37.42'	37.42'
MW-6	69.46'	---	---	---	---	---	36.91'*	36.91'	37.01'	36.85'	36.95'	36.95'
MW-7	74.12'	---	---	---	---	---	---	35.28'	35.23'	---	35.34'	35.30'
MW-8	74.62'	---	---	---	---	---	---	---	35.30'	35.19'	35.36'	35.32'
MW-9	66.56'	---	---	---	---	---	---	---	---	---	---	---
MW-10	74.33'	---	---	---	---	---	---	---	---	---	---	---

* This water level reading was taken on 06/04/86.
All readings are in feet mean sea level.

TABLE 4-2
WATER LEVEL ELEVATIONS IN MONITORING WELLS
REICH FARM SITE
DOVER TOWNSHIP, NEW JERSEY
PAGE TWO

Well No.	Elevation of Measuring Point	06/12/86 Elevation	06/13/86 Elevation	06/16/86 Elevation	06/17/86 Elevation	06/18/86 Elevation	06/19/86 Elevation	06/20/86 Elevation	06/23/86 Elevation	06/24/86 Elevation	06/25/86 Elevation	06/27/86 Elevation
MW-1	75.76'	38.10'	38.10'	38.29'	38.18'	38.12'	38.08'	38.07'	38.09'	---	---	38.07'
MW-2	75.66'	38.25'	38.19'	38.23'	38.12'	38.19'	38.18'	38.17'	38.16'	38.16'	---	38.26'
MW-3	70.50'	37.01'	36.99'	37.01'	36.97'	36.96'	36.96'	36.97'	36.97'	---	36.87'	36.90'
MW-4	68.74'	36.75'	36.73'	36.77'	36.73'	36.72'	36.70'	36.71'	36.70'	36.70'	---	36.65'
MW-5	70.47'	37.42'	37.38'	37.42'	37.32'	37.47'	37.34'	37.37'	37.36'	---	---	37.32'
MW-6	69.46'	36.89'	36.87'	36.89'	36.80'	36.92'	36.80'	36.82'	37.00'	36.80'	---	36.76'
MW-7	74.12'	35.17'	35.17'	35.26'	35.11'	35.16'	35.08'	35.20'	35.16'	35.20'	35.05'	35.13'
MW-8	74.62'	35.19'	35.19'	35.38'	35.25'	35.20'	35.19	35.21'	35.22'	35.19'	35.20'	35.08'
MW-9	66.56'	---	---	---	35.68'	35.75'	35.75'	35.77'	35.77'	---	---	35.71'
MW-10	74.33'	---	---	---	35.64'	35.69'	35.64'	35.76'	35.45'	35.72'	---	35.66'

All readings are in feet mean sea level.

Aquifer Testing

Selected monitoring wells were used for aquifer testing to determine aquifer characteristics and to estimate groundwater flow velocity across and away from the site.

A pumping test was performed in monitoring well MW-3. The well was pumped for 8 hours at 37.5 gpm using a Franklin Electric 5 horsepower submersible pump. The pump was powered by a portable generator and water was discharged through 2 inch PVC pipe 200 feet away from the well. The drawdowns in pumping well MW-3 and observation well OW-1 located 22.5 feet away, were recorded during an 8 hour pumping period, and during recovery for 100 minutes after the pump was shut off.

Groundwater Sampling

Groundwater sampling was performed throughout the Reich Farm Site investigation. A discussion of groundwater sampling analytical results are presented in Section 4.7.1.

4.3 Regional Geology

The Reich Farm Site is located in the Atlantic Coastal Plain physiographic province, approximately 8 miles from the Atlantic Ocean, in the Pleasant Plains section of Toms River, New Jersey. The topography in the area of the site has a gently undulating surface lying within 80 feet of sea level. The site is situated on a highland lying between the Toms River, which is the principle drainage of the region, and an unnamed intermittent stream to the east, which drains into Toms River estuary.

The Toms River area is underlain by sands, gravels, silts, and clays. This unconsolidated material of Holocene to Cretaceous age dips toward the east in Ocean County. Early Paleozoic and Precambrian crystalline rocks underlie this coastal plain deposit at depths of 1000 to 4000 feet. Figure 4-2 describes the stratigraphic sequence in the Toms River area. The coastal plain strata of interest are the Eocene age Manasquan Formation, the Miocene age Kirkwood Formation, and the Miocene-Pliocene age Cohansey Formation. The following discussion is taken primarily from Anderson and Appel (1969).

The Manasquan Formation consists predominantly of fine glauconitic sand and clay. Locally, the upper 10 feet is a coarse quartz sand that produces significant quantities of water.

ERA	PERIOD	EPOCH	GROUP	FORMATION		
CENOZOIC	TERTIARY	PLIOCENE		COHANSEY SAND		SAND, QUARTZ, FINE TO COARSE GRAINED LOCALLY CLAYEY AND CLAY, UNCONFINED AQUIFIER
		MIOCENE		KIRKWOOD		SAND, QUARTZ, VERY FINE TO MEDIUM AND COARSE GRAINED, MICACEOUS, LIGNITIC, SILT, GRAY CLAY, AND FINE GRAVEL LENSES, CONFINED AQUIFIER
		Eocene		MANASQUAN		SAND, QUARTZ-GLAUCONITE MEDIUM TO COARSE GRAINED, CLAYEY, FOSSILIFEROUS, AQUITARD LOCALLY WATERBEARING
		PALEOCENE	BARCOCAS	VINCENTOWN		CALCARENITE, FINE TO MEDIUM GRAINED SAND, QUARTZ GLAUCONITIC, FINE TO COARSE GRAINED, CLAYEY
				HORNERSTOWN		SAND, GLAUCONITE, MEDIUM TO COARSE GRAINED, CLAYEY, FOSSILIFEROUS AQUITARD
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	MONMOUTH	RED BANK SAND		SAND, QUARTZ-GLAUCONITE, FINE TO COARSE GRAINED CLAYEY, LIGNITIC, AQUITARD
				NAVESINK		SAND, GLAUCONITE, FINE TO COARSE GRAINED, CLAYEY, FOSSILIFEROUS, AQUITARD
				MOUNT LAUREL SAND		SAND, QUARTZ, FINE TO COARSE GRAINED, GLAUCONITIC FOSSILIFEROUS, CONFINED AQUIFIER
			MATAWAN	WENONAH		SAND, QUARTZ, FINE GRAINED, MICACEOUS, LIGNITIC AND SILT, CLAYEY, CONFINED AQUIFIER
				MARSHALLTOWN		SAND, GLAUCONITE AND QUARTZ, FINE TO MEDIUM GRAINED, CLAYEY, FOSSILIFEROUS, AQUITARD
				ENGISHTOWN		SAND, QUARTZ, FINE TO MEDIUM GRAINED, MICACEOUS, LIGNITIC, CLAY SEAMS, CONFINED AQUIFIER
				WOODBURY CLAY		CLAY AND SILT, GLAUCONITIC AND FOSSILIFEROUS, AQUITARD
				MERCHANTVILLE		
				MAGOTHY		SAND, QUARTZ, VERY FINE TO MEDIUM GRAINED, GLAUCONITIC, MICACEOUS, CLAY, SEVERAL CONFINED AQUIFIERS
				RARITAN		SAND, QUARTZ, FINE TO COARSE GRAINED ARKOSIC, SIDERITIC, CLAY, SEVERAL CONFINED AQUIFIERS
PRECAMBRIAN AND EARLY PALEOZOIC PRECAMBRIAN AND EARLY CAMBRIAN				BEDROCK		SCHIST, GNEISS, PEGMATITE, AND GABBRO BEDROCK

SOURCE: ANDERSON, GEOLOGY AND HYDROGEOLOGY OF OCEAN COUNTY, NJ

GENERALIZED REGIONAL STRATIGRAPHIC COLUMN **REICH FARM SITE, PLEASANT PLAINS, NJ**

NOT TO SCALE

IMS

ENGINEERS - ARCHITECTS, P.C.
115 Metro Park
Rochester, NY 14623
FIGURE

The Kirkwood Formation outcrops in northern Ocean County where it is about 50 feet thick. In the subsurface it dips an average of 22 feet per mile to the southeast, and thickness to greater than 500 feet in southern Ocean County. The upper surface of the Kirkwood Formation is a broadly undulating surface that exhibits local variation in the average regional dip. Kirkwood lithology is primarily a grey micaceous lignitic, silty, fine quartz sand reportedly overlying a dark brown, micaceous lignitic silty clay, and near the coast, a coarse grained sand at its base.

The Cohansey Formation overlies the Kirkwood Formation. Across Ocean County, the Cohansey Strata range from 0 to 300 feet in thickness depending upon the surficial topographic relief, distance from the outcrop, and relief on the upper surface of Kirkwood Formation. The regional dip is 10 feet per mile to the southeast.

The lithology of the Cohansey Formation consists predominantly a yellow brown goethitic, fine to coarse quartz sand with minor amounts of pebbly sand, silty to clayey sand, and interbedded massive clays. Above the water table oxidized strata range from yellow orange to deep red. Regionally, the Cohansey Formation exhibits lithologies characteristic of various nearshore to deltaic depositional environments. There are irregular and discontinuous beds, lenses, and stringers of clay, sandy clay, and gravel. These changes occur in both vertical and horizontal directions (Rhodehamel, 1979).

The contact of the Kirkwood and Cohansey Formations is reportedly either gradational or a minor unconformity (Lasphording and Lodding, 1969). It is characterized by gradational to abrupt changes from silty, fine sand to coarse- medium sand.

Two aquifers occur in the shallow sequence that is the focus of this investigation. The principle source of water for Dover Township is the shallow water table aquifer in the Cohansey Formation. The deep aquifer, which is commonly referred to as "the Kirkwood aquifer," is 10 to 15 feet of coarse grained sand that occurs either in the base of the Kirkwood Formation or in the top of the Manasquan Formation. The two aquifers are separated by an aquitard consisting of the clayey silts of the Kirkwood Formation.

The aquifers of interest in the study area are the aquifers in the Cohansey and Kirkwood Formations. Both Cohansey and Kirkwood water bearing formations are recharged by direct infiltration of precipitation. Seventy-four percent of all industrial and domestic wells in the area tap the Cohansey water table aquifer.

Groundwater flow direction in the water table aquifer is controlled by topography and locations of groundwater discharge points (surface waters), with the water table reflecting the overlying landforms. Therefore in the study area the groundwater flow direction in this aquifer is expected to be southwest toward Toms River.

The pH of Cohansey groundwater ranges from 3.1 to 7.6 and the median pH is 5.3. High concentrations of iron and manganese are common. Chloride levels generally are less than 20 mg/l. Sulfate also occurs naturally in the groundwater in the Toms River area and is reduced to sulfide by bacteria under anaerobic conditions; sulfide combines with hydrogen to form hydrogen sulfide. Calcium, iron, magnesium, and manganese determine the hardness of water; Cohansey groundwater contains less than 60 mg/l of these elements.

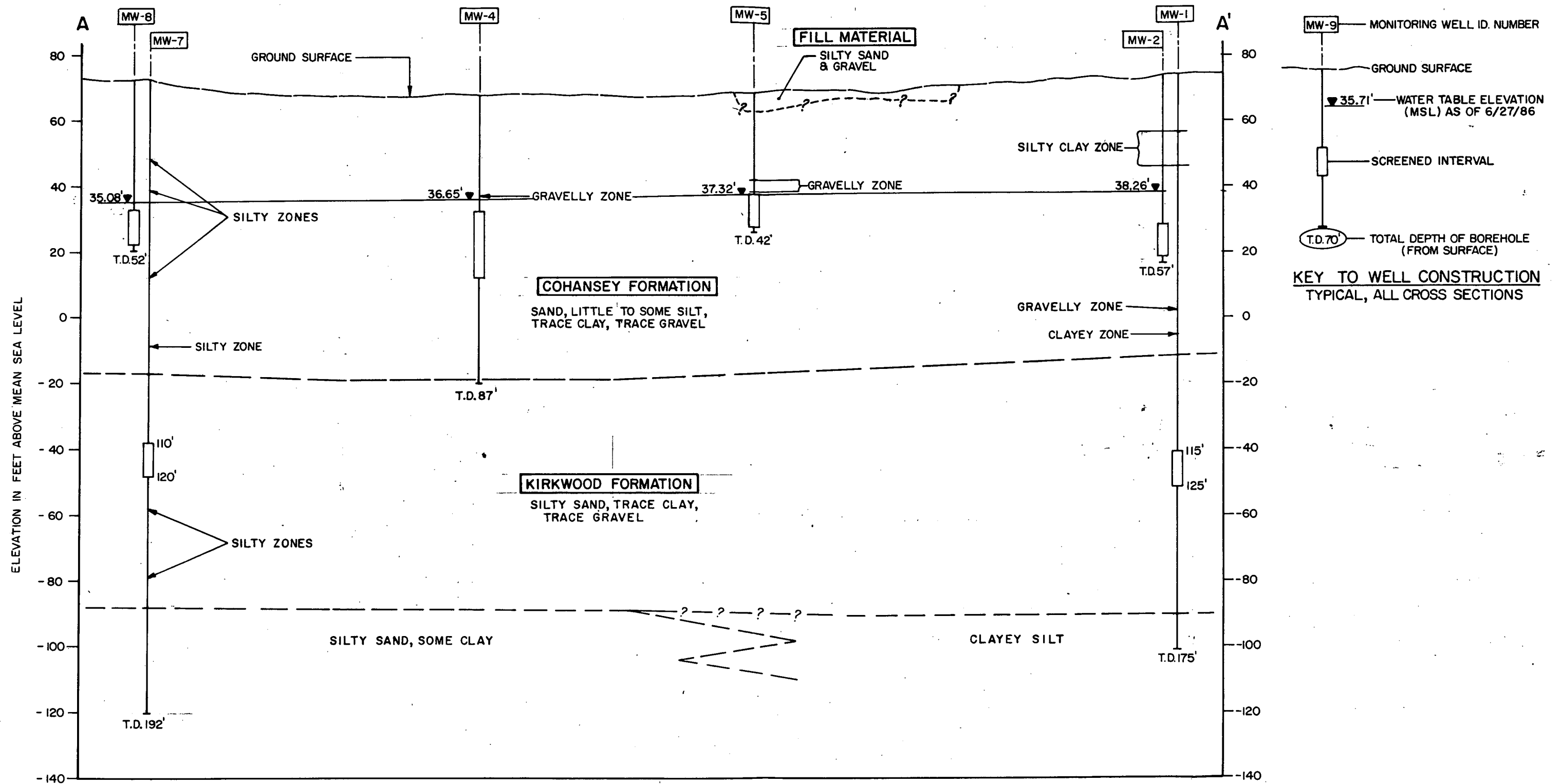
Between the Cohansey aquifer and the aquifer in the Kirkwood Formation are the fine sands, clays and silts of the Kirkwood Formation. The interval serves as the functional aquitard in the Toms River area, and defines the base of the water table aquifer. Within the Kirkwood are permeable zones of medium sand that can serve as intraformational aquifers. A small number of area wells tap these intervals. Groundwater in the Kirkwood has a median pH of 6.7, low hardness, and an average temperature of 16°C (OCPB, 1978). The Kirkwood becomes increasingly valuable along the coast where a basal sand aquifer thickens to as much as 300 feet and is a dependable source of water (Anderson and Appel, 1969).

4.5 Site Specific Geology

Site specific geologic conditions were interpreted from data obtained in the RI field investigation. Geologic cross sections have been developed for the site from boring log and borehole geophysical information. Cross section locations are shown in Figure 4-1 and cross sections are presented in Figures 4-3 through 4-5.

The subsurface material encountered in the study area consists of both fill material and coastal plain sediments. Fill material was deposited on the site property and the coastal plain sediments were encountered underlying and adjacent to the fill areas.

The fill material encountered during the field investigation consists primarily of silty sand and gravel. This material was deposited in trenches that were dug when drums and contaminated soil were removed during past remedial activities. Visible discoloration of soils resulting from waste dumping activities was not encountered during the field investigation, however, one soil boring, SB-7



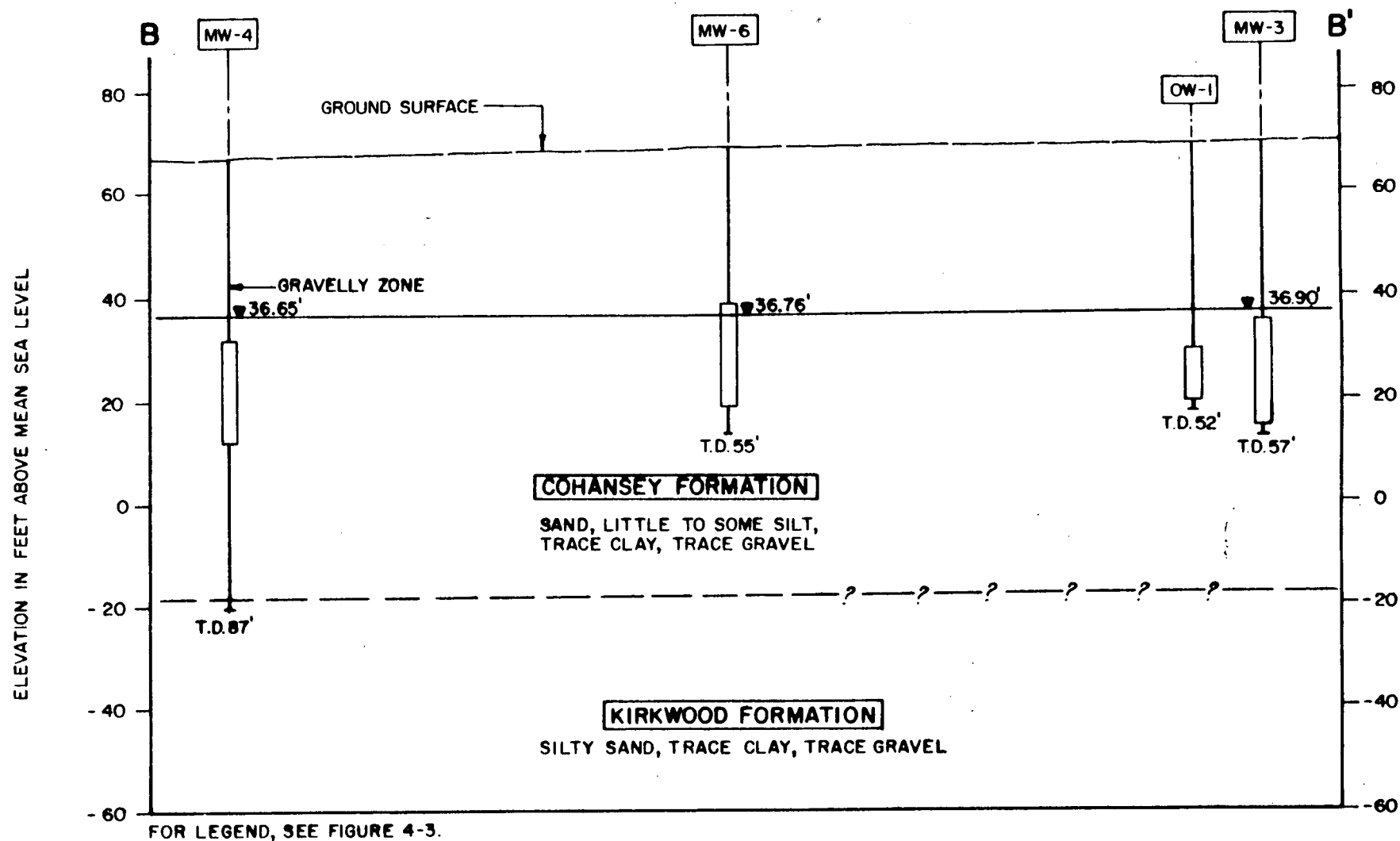


FIGURE 4-4
HYDROGEOLOGIC CROSS SECTION B-B'
REICH FARM SITE, DOVER TOWNSHIP, NJ
 SCALE: 1" = 50' HORIZ., 1" = 30' VERT.

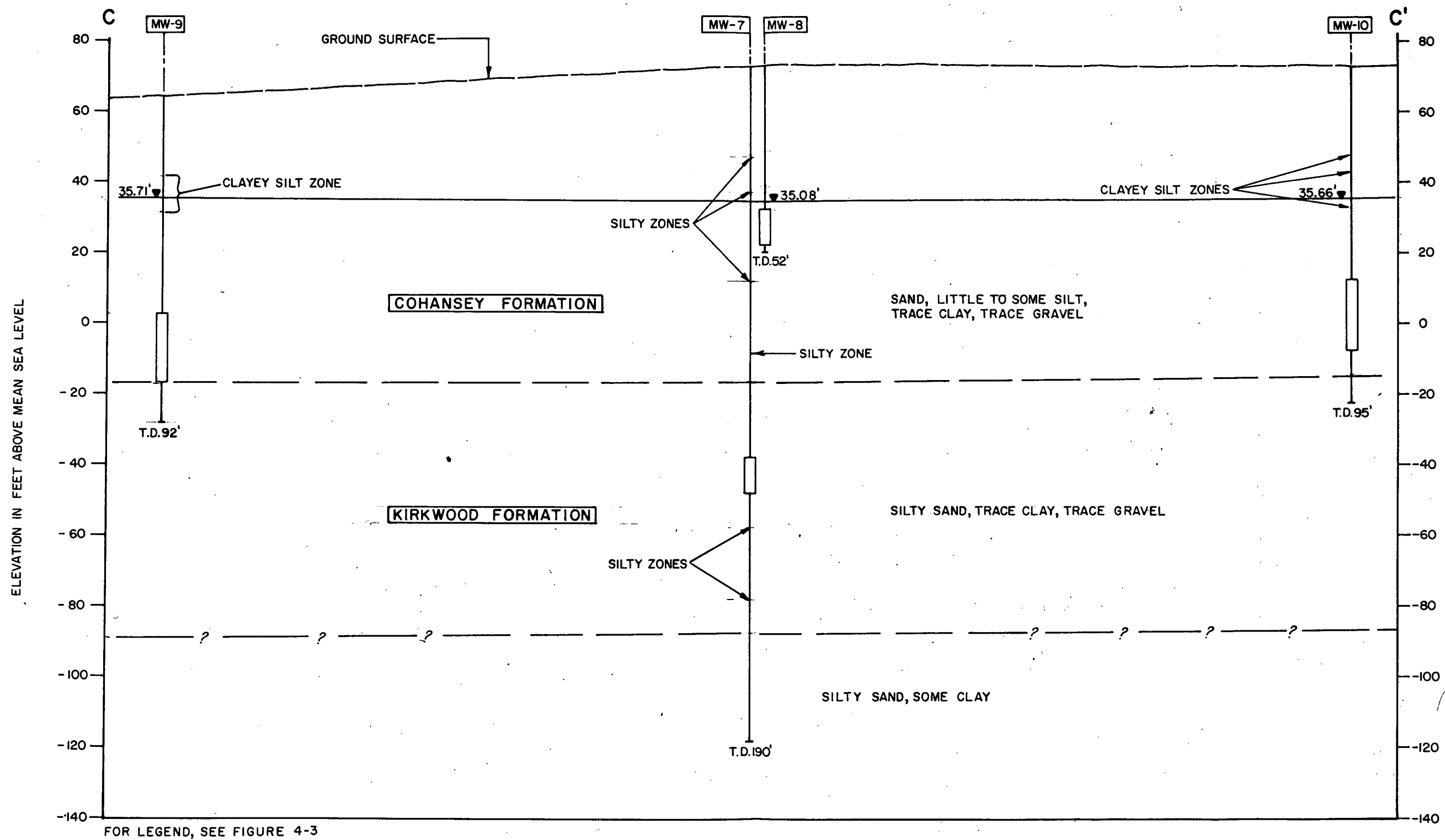
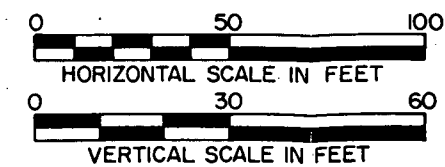


FIGURE 4-5
HYDROGEOLOGIC CROSS SECTION C-C'
REICH FARM SITE, DOVER TOWNSHIP, NJ



encountered twisted steel which could possibly have been a buried drum. The fill material was encountered in 21 of the 28 soil borings drilled in the soil investigation and in monitoring well MW 5 in the hydrogeological investigation. The depth of the fill material ranged from 0 to 10 feet according to the drilling information. The soil boring logs are located in Appendix B.

The coastal plain sediments encountered during the field investigation were of the Cohansey and underlying Kirkwood formations. The Cohansey Formation immediately underlies the fill areas where present, and is present at the ground surface in areas adjacent to the fill. The Cohansey Formation consists of a light brown to orange sand with little to some silt, trace clay, and trace gravel. In the Cohansey Formation discontinuous zones containing predominantly clay, silt, gravel, or a combination thereof, were encountered during the drilling investigation. The total depth of the Cohansey Formation ranges from 80 to 90 feet in the study area.

Underlying the Cohansey Formation is the Kirkwood Formation. The Kirkwood Formation characteristically contains more silt than the Cohansey and is of a different color, particularly dark brown to grey black to black. A clayey zone was encountered in MW-1 at 79 feet and a silty zone was encountered in MW-7 at 81 feet. These two zones form the contact zone between the Cohansey and Kirkwood Formations. The Kirkwood formation consists of a silty sand with trace clay and trace gravel. However, discontinuous silty zones were encountered and a silty sand with some clay was encountered in MW-7 at 160 feet to 192 feet and a clayey silt zone was encountered in MW-1 at 165 to 175 feet. These two boreholes were terminated in the clay and silt zones. Therefore, the thickness of the Kirkwood Formation underlying the study area is not known.

4.6 Site Specific Hydrogeology

Occurrence of Groundwater

Groundwater occurs in the study area in the coastal plain deposits. The occurrence of groundwater beneath the site was investigated and the presence of groundwater flow systems was defined in both the Cohansey and Kirkwood Formations. Both groundwater flow systems in the Cohansey and Kirkwood aquifers are under unconfined conditions. Eight monitoring wells MW-2 through MW-6, MW-8, MW-9, MW-10, and observation well OW-1 were installed into the Cohansey aquifer. The depth to the contact zone between Cohansey and the Kirkwood Formations beneath the site is about 80 feet below the ground surface. This contact zone i.e. the bottom of the Cohansey aquifer, has been determined during drilling monitoring wells based on lithologic changes.

A discontinuous clayey zone and silty zone was encountered approximately 80 feet below the ground surface. This zone may act as a leaky confining layer beneath the site. MW-1 and MW-7 penetrated this unit and monitoring wells were installed into the upper zone of the Kirkwood Formation. The water level elevation in monitoring wells screened in the Cohansey Formation versus water level elevations in monitoring wells screened in the Kirkwood Formation indicate that a hydraulic connection exists between these two units. Depth to the groundwater in the study area range from 37 to 39 feet below the ground surface. The saturated thickness of the sandy deposit in the Cohansey Formation is approximately 50 feet.

The groundwater flow direction in the water table aquifer is south in the site area which may be influenced by the pumping of Toms River municipal wells located approximately 1 mile south of the site. These wells reportedly pump 5.75 million gallons of water per day. The average hydraulic gradient was calculated to be 0.003, which is typical of coastal plain aquifers. A steeper gradient is observed in the southern portion of the site than in the northern site area. This variation may be caused by the changes in formation permeabilities or the influence of the Toms River municipal wells. Figure 4-6 is a water table contour map of the site area.

The vertical gradient in the study area was determined through comparison of water levels in the monitoring wells installed in the Cohansey and Kirkwood Formations. These wells were installed adjacent to each other (cluster wells) at two locations in the study area. Cluster wells MW-1 and MW-2 are situated in the north-eastern portion of the study area and wells MW-7 and MW-8 are located in the southern study area. Wells MW-2 and MW-8 are screened in the Cohansey Formation and wells MW-1 and MW-7 are installed in the Kirkwood Formation. A slight downward hydraulic gradient was observed from the water level elevations in these monitoring wells.

Hydraulic Characteristics

The hydraulic characteristics of the Cohansey Formation was measured during the field investigation through a pumping test in MW-3. This test involved lowering the water level in the well by pumping, then measuring the rate of discharge and drawdown in MW-3 and observation well OW-1. Recovery of water levels within the pumping well and the observation well was recorded.

The pumping test on MW-3, performed in conjunction with an observation well, OW-1, presented effective test conditions. The results from pumping MW-3 were analyzed, using a modification of the Theis formula (Streetslova, 1974), to determine aquifer characteristics. The calculations are shown in Appendix C-4. Analysis of the pumping test conducted on monitoring well MW-3 demonstrates an

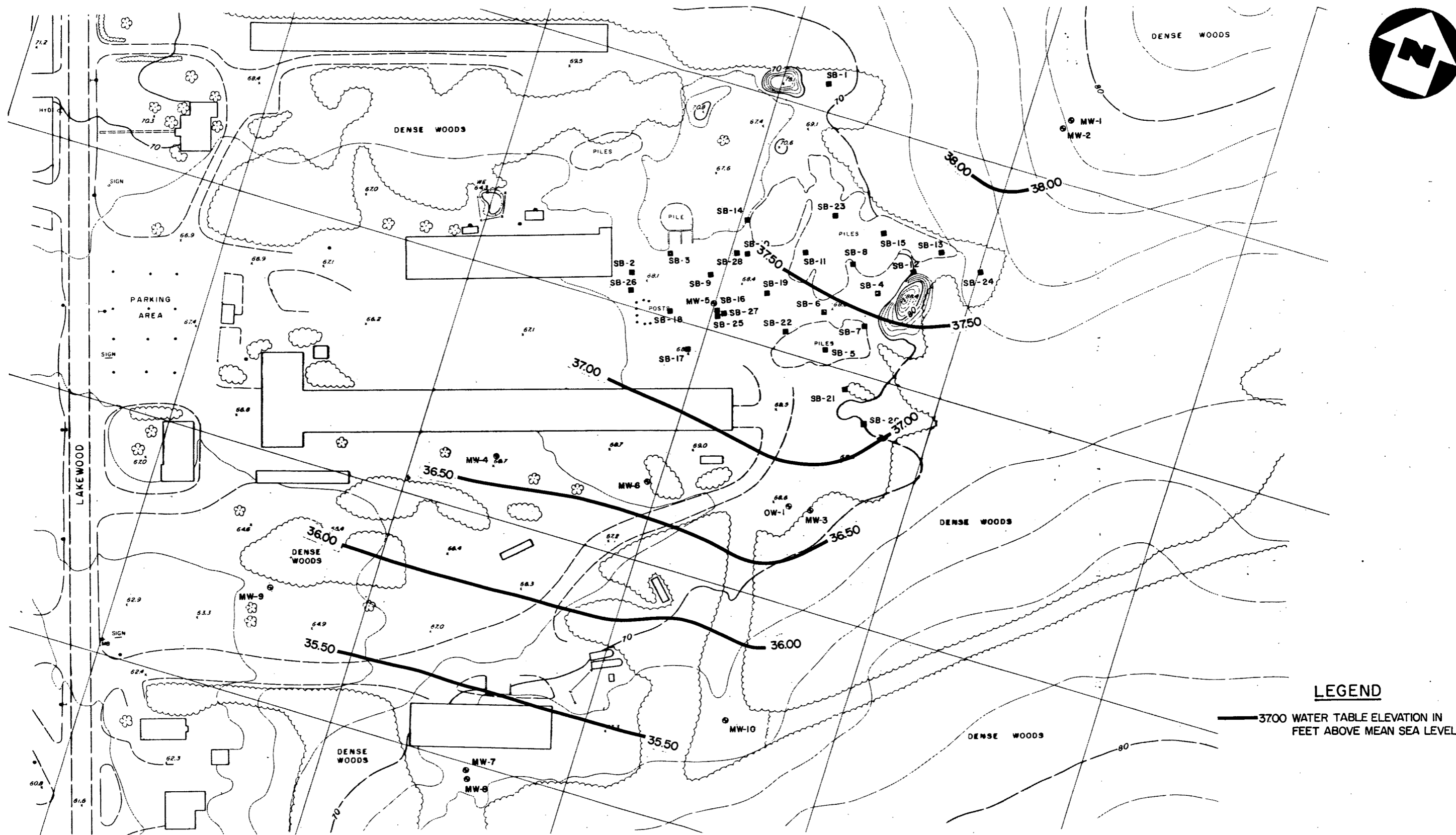


FIGURE 4-6
 WATER TABLE CONTOURS - 6/27/86
 REICH FARM SITE, DOVER TOWNSHIP, NJ

aquifer transmissivity of 24,400 gpd/ft. Considering the pumping test in well MW-3 as a representative test for the determination of the hydraulic characteristics of the Cohansey Formation, the aquifer transmissivity is 24,400 gpd/ft. Assuming 50 feet of the saturated thickness, the average hydraulic conductivity for the Cohansey Formation is 488 gpd/ft² or 2.3×10^{-3} cm/sec.

The average groundwater seepage velocity through the Cohansey Formation beneath the site area is calculated to be 0.93 ft/day (340 feet/year), using an average hydraulic conductivity value of 2.3×10^{-3} cm/sec, an average gradient of 0.003 and an effective porosity of 0.20 (average specific yield for the Cohansey aquifer in Ocean County (OCPB 1978).

The value of average seepage velocity in the Kirkwood Formation was not estimated because of insufficient data.

4.7 Groundwater Sampling Program

Groundwater samples were collected from 10 on-site monitoring wells (listed in Table 4-1); 8 residential wells (listed in Table 4-3); and 9 Toms River Water Company Production Wells and 1 existing monitoring well on Dugan Lane (listed in Table 4-4). Figure 4-7 shows onsite well locations. Figure 4-8 shows the off site well locations.

Five downgradient and one upgradient off site Kirkwood wells were sampled. Ten downgradient and two upgradient off site Cohansey wells were sampled.

Due to the closure of wells in Zone 1 and the availability of municipal water, the nearest existing well downgradient of the site is approximately 2400 feet south-southwest. The monitoring well on Dugan Lane, installed into the Cohansey, is approximately 4100 feet south southeast, and wells in the Parkway wellfield range from 4700 feet to 5700 feet from the site.

The existing well nearest to the site is at the Villager Bar (Figure 4-8, well No. 7) approximately 1500 feet north - northwest.

All groundwater samples were analyzed for the presence of Hazardous Substance List (HSL) volatiles, semivolatiles, inorganics (total metals), and pesticide/PCB's. Additional sample aliquots were collected for the analysis of conventional water quality parameters, petroleum hydrocarbons, and Total Organic Halogen. Laboratory analyses were performed under the EPA Contract Laboratory

TABLE 4-3

**EXISTING RESIDENTIAL WELLS SAMPLED DURING THE REMEDIAL INVESTIGATION
REICH FARM SITE**

Owner/Address	Sample No.	Date Sampled	Well Number	Aquifer
Taras Residence	RF-RW-001	4/24/86	1	Cohansey
308 Ashford (irrigation Well)	RF-MW-002	6/27/86		
Zagari Residence 1272 Whiteville	RF-RW-003 RF-MW-015	4/24/86 6/26/85	2	Cohansey
Bouch Residence 1379 Whitesville	RF-RW-003 RF-RW-003A RF-MW-014	4/24/86 4/24/86 6/26/86	3	Kirkwood
Petroski Farm 17 Monroe (irrigation well)	RF-RW-004	4/24/86 6/26/86	4	Cohansey
Miller Residence 527 Woodview	RF-RW-005 RF-RW-016	4/24/86 6/26/86	5	Kirkwood
Westra Residence 1247 Silverton	RF-RW-006 RF-MW-017	4/24/86 6/26/86	6	Cohansey
Villager Bar Lakewood Road	RF-RW-013	4/25/86	7	Cohansey
Jewish Community Center Whitty Road	RF-MW-012	6/26/86	8	Kirkwood

TABLE 4-4
TOMS RIVER WATER COMPANY (TRWC) WELLS SAMPLED DURING
THE REMEDIAL INVESTIGATION
REICH FARM SITE

Owner/Address	Sample No.	Date Sampled	Well Designation	Aquifer
TRWC Well #20 Corner of Whitesville and Indian Head Roads	RF-MW-019	6/26/86	TRWC #20	Cohansey
TRWC Well #22 Parkway Wellfield	RF-MW-020 RF-MW-020A	6/27/86	TRWC #22	Cohansey
TRWC Well #23 Parkway Wellfield	RF-MW-021	6/27/86	TRWC #23	Kirkwood
TRWC Well #24 Parkway Wellfield	RF-RWO--8	5/6/86	TRWC #24	Cohansey
TRWC Well #25 Parkway Wellfield	RF-RW-007	5/6/86	TRWC #25	Kirkwood
TRWC Well #26 Parkway Wellfield	RF-MW-018	6/27/86	TRWC #26	Cohansey
TRWC Well #27 Parkway Wellfield	RF-RW-009	5/6/86	TRWC #27	Kirkwood
TRWC Well #28 Parkway Wellfield	RF-RW-011	5/6/86	TRWC #28	Cohansey
TRWC Well #29 Parkway Wellfield	RF-RW-010	5/6/86	TRWC #29	Cohansey
TRWC Dugan Lane Monitoring Well	RF-MW-011	6/26/86	TRWC-MWD	Cohansey

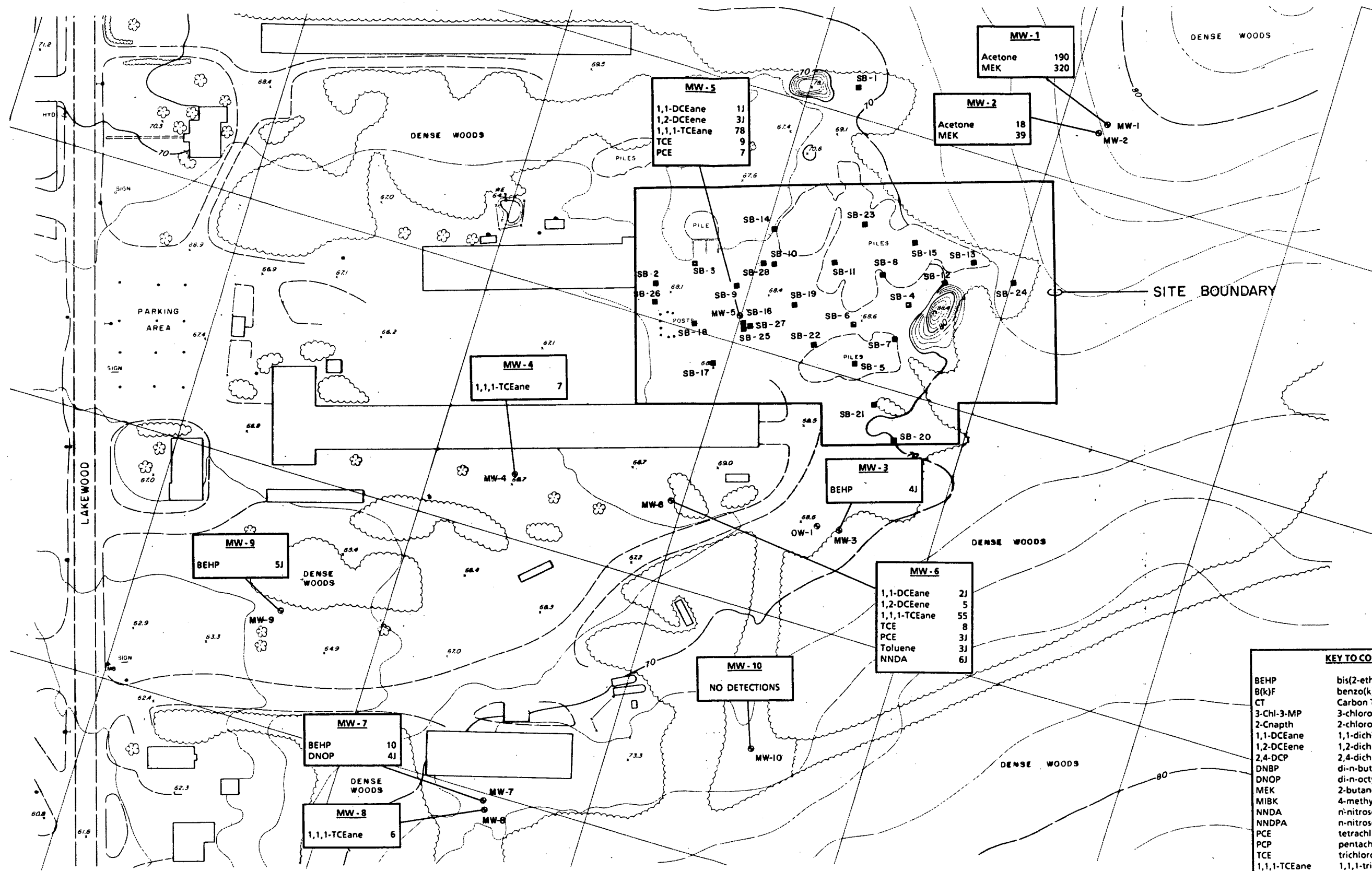
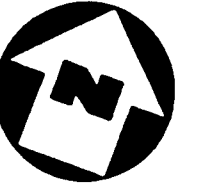
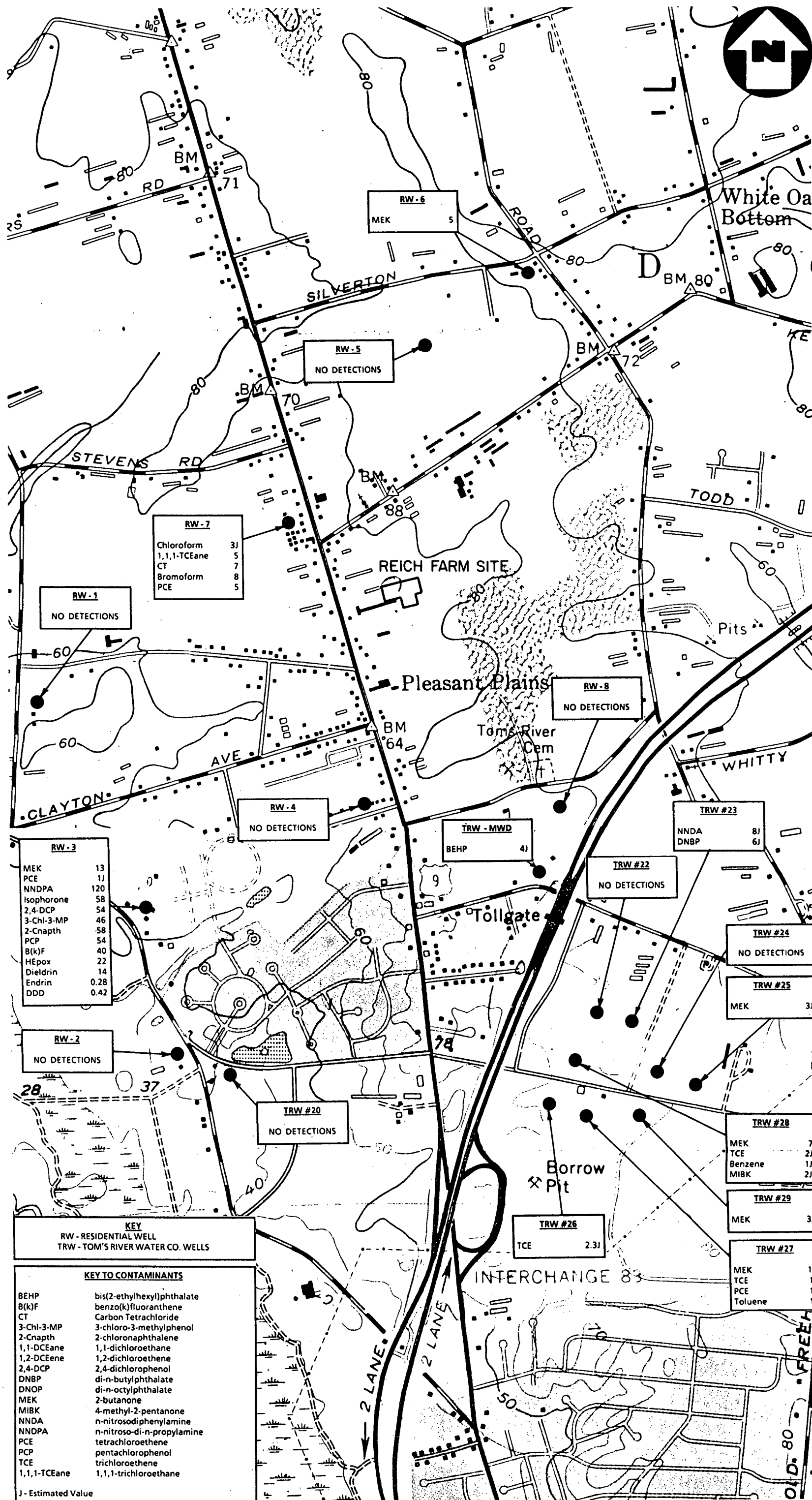


FIGURE 4-7
HSL ORGANIC GROUNDWATER CONTAMINATION IN SITE MONITORING WELLS
REICH FARM SITE, DOVER TWP., NJ





Program. Specific conductance, pH, Eh and temperature were determined in the field at the time of sampling.

4.7.1 Groundwater Sampling Results

Analytical results for monitoring wells are presented in Appendix E; for TRWC wells in Appendix F-1; and for residential wells in Appendix F-2. Table 4-5 summarizes the sampling results for HSL organics for on site wells, TRWC wells, and residential wells. Table 4-6 summarizes the sampling results for HSL inorganics.

The occurrence of HSL organic contaminants in the onsite monitoring wells is illustrated in Figure 4-7.

Reported concentrations of HSL compounds in groundwater on the Reich Farm site are low. The maximum reported levels were for acetone (190 µg/L) and 2-butanone (320 ug/L) from the deep upgradient well, MW1. Acetone (18 ug/L) and 2-butanone (39 Ug/L) are also reported from the shallow upgradient well MW2. No other contaminant is reported from the upgradient wells and both acetone and 2-butanone are not reported in wells downgradient of the contaminated soils. Other contaminants prevalent in the downgradient contaminated water are not reported from the upgradient wells. Both acetone and 2-butanone potentially result from the contamination of analytical apparatus.

Volatile organic compounds are the best indicator of groundwater contamination at the Reich Farm Site. Groundwater contamination in site monitoring wells, as measured by total volatile organics (TVO), is most prevalent at wells MW5 and MW6. Well MW5 is located on site in the former drum storage area. As Figure 4-7 shows, the contamination detected here is solely comprised of chlorinated aliphatics. This is inconsistent with the compounds detected in contaminated soil-boring SB3, which is approximately 50 feet away and exhibited predominantly monocyclic aromatic compounds. Well MW6, located approximately 150 feet directly south (downgradient) of MW5, demonstrates almost identical contamination as MW5. MW3 is located approximately 150 feet directly downgradient of the contaminated soil of the former trench area (SB4), but exhibits no volatile organic contamination. The clay layer identified beneath the soil borings SB4, SB6, and SB7 may effectively inhibit the rate of infiltration and consequent contaminant transport via leaching. It is entirely possible that MW3 may exhibit contamination under different seasonal water-table conditions.

TABLE 4-5

**OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN GROUNDWATER
REICH FARM SITE**

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Volatiles (µg/l)</u>									
acetone	2/11	18.9	18-190	--	--	--	--	--	--
2-butanone	2/11	32.6	39-320	4/10	2.7	3-14	2/9	2	5-13
4-methyl-2-pentanone	--	--	--	1/10	0.2	2	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--
carbon tetrachloride	--	--	--	--	--	--	1/9	0.8	7
1,1-dichloroethane	2/11	0.3	1-2	--	--	--	--	--	--
methylene chloride	--	--	--	--	--	--	--	--	--
tetrachloroethene	2/11	0.9	3-7	1/10	0.1	1	2/9	0.7	1-5
1,1,1-trichloroethane	4/11	13.3	6-78	--	--	--	1/9	0.6	5
trichloroethene	2/11	1.5	8-9	3/10	0.5	1-2.3	--	--	--
trans-1,2-dichloroethene	2/11	0.7	3-5	--	--	--	--	--	--
chloroform	--	--	--	--	--	--	1/9	0.3	3
toluene	1/11	0.3	3	1/10	0.1	1	--	--	--
ethylbenzene	--	--	--	--	--	--	--	--	--
styrene	--	--	--	--	--	--	--	--	--
total xylenes	--	--	--	--	--	--	--	--	--
benzene	--	--	--	1/10	0.1	1	--	--	--
chlorobenzene	--	--	--	--	--	--	--	--	--
bromoform	--	--	--	--	--	--	1/9	0.9	8
cis-1,3-dichloropropene	--	--	--	--	--	--	--	--	--

TABLE 4-5
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN GROUNDWATER
REICH FARM SITE
PAGE TWO

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Acid Extractables (µg/l)</u>									
phenol	--	--	--	--	--	--	--	--	--
pentachlorophenol	--	--	--	--	--	--	1/9	6.0	54
2,4-dichlorophenol	--	--	--	--	--	--	1/9	6.0	54
4-chloro-3-methylphenol	--	--	--	--	--	--	1/9	5.1	46
<u>Base/Neutral Extractables (µg/l)</u>									
bis(2-ethylhexyl)phthalate	4/11	2.1	4-10	--	--	--	--	--	--
di-n-octyl phthalate	1/11	0.4	4	--	--	--	--	--	--
di-n-butyl phthalate	--	--	--	1/10	0.6	6	--	--	--
diethyl phthalate	--	--	--	--	--	--	--	--	--
butylbenzyl phthalate	--	--	--	--	--	--	--	--	--
benzo(k)fluoranthene	--	--	--	--	--	--	1/9	4.4	40
benzo(a)anthracene	--	--	--	--	--	--	--	--	--
fluoranthene	--	--	--	--	--	--	1/9	6.4	58
pyrene	--	--	--	--	--	--	--	--	--
2-chloronaphthalene	--	--	--	--	--	--	1/9	13	120
isophorone	--	--	--	--	--	--	1/9	6.4	58
1,2-dichlorobenzene	--	--	--	--	--	--	--	--	--
n-nitrosodi-n-propylamine	--	--	--	--	--	--	1/9	13	120
n-nitrosodiphenylamine	1/11	0.5	6	1/10	0.8	8	--	--	--

TABLE 4-5
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS IN GROUNDWATER
REICH FARM SITE
PAGE THREE

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Pesticides/PCBs (µg/l)</u>									
BHC	--	--	--	--	--	--	--	--	--
heptachlor epoxide	--	--	--	--	--	--	1/9	2.4	22
heptachlor	--	--	--	--	--	--	--	--	--
endrin	--	--	--	--	--	--	1/9	0.03	0.28
aldrin	--	--	--	--	--	--	--	--	--
dieldrin	--	--	--	--	--	--	1/9	1.6	14
endosulfan I	--	--	--	--	--	--	--	--	--
chlordane	--	--	--	--	--	--	--	--	--
4,4'-DDE	--	--	--	--	--	--	--	--	--
4,4'-DDD	--	--	--	--	--	--	1/9	0.05	0.42
PCB-1242	--	--	--	--	--	--	--	--	--
PCB-1248	--	--	--	--	--	--	--	--	--

TABLE 4-6

**OCCURRENCE AND DISTRIBUTION OF HSL INORGANICS IN GROUNDWATER
REICH FARM SITE**

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Inorganics (µg/l)</u>									
aluminum	11/11	230	78-903	7/10	218	57-783	7/7	126	59-191
barium	3/11	11.3	39-44	7/10	33	32-80	3/7	20	40-55
beryllium	--	--	--	--	--	--	1/7	0.29	2.0
cadmium	2/11	1	5.0-6.0	--	--	--	1/7	39	273
calcium	11/11	7,690	3,070-16,500	5/10	1,519	2,430-4,230	7/7	2,477	756-5,070
chromium	1/11	1.6	18	--	--	--	--	--	--
cobalt	--	--	--	2/10	1.5	4-11	--	--	--
copper	8/11	32.4	12-127	6/10	9	5-23	6/7	79	23-190
iron	11/11	3,023	324-23,400	7/10	27	16-1,648	7/7	325	70-1,290
lead	7/11	14	9.9-56	2/10	6.9	11-58	4/7	14	8.4-23
magnesium	11/11	185	564-2,770	5/10	956	966-2,590	7/7	2,251	1,520-3,250
manganese	11/11	107.6	23-262	5/10	8	14-22	7/7	21	5-55
mercury	11/11	0.4	0.3-0.6	4/10	0.14	0.1-0.7	2/7	0.1	0.2-0.5
nickel	2/11	3.6	19-21	1/10	2.1	21	1/7	12	86
potassium	11/11	3,953	671-6,950	5/10	1,131	1,870-3,200	7/7	2,164	1,080-3,370
selenium	--	--	--	--	--	--	1/7	0.19	1.3
silver	--	--	--	--	--	--	--	--	--
sodium	11/11	13,400	5,440-41,800	10/10	8,828	2,762-18,500	7/7	8,684	5,830-16,200
tin	--	--	--	--	--	--	1/7	8	58
vanadium	1/11	1.1	12	1/10	1.3	13	1/7	1.7	12
zinc	11/11	850.6	21-5,350	6/10	11.6	7-40	5/7	322	70-1,800

Metals concentrations for monitoring wells are summarized in Table 4-6. No apparent pattern of metals distributions relative to the zone of contaminated soils is evident. As stated in Section 3.5, the site's waste disposal history does not indicate a potential metals problem.

Oil and grease, and petroleum hydrocarbons were not reported in any water analyses.

HSL organics analyses for municipal wells and residential wells are also summarized in Table 4-5. The occurrence of HSL contaminants in off site wells is illustrated in Figure 4-8.

Only three residential wells, well RW-3 (the Bouch residence), well RW-6 (the Westra residence), and well RW-7 (the Villager Bar), exhibit HSL organics above the method detection limit. In the case of the Bouch residence well, many of the contaminants are from the semi-volatile aliquot and several are pesticides. Conspicuously, a duplicate sample showed no HSL organics. The Westra residence well is located approximately 4,000 feet upgradient of the site and exhibited 5 µg/L of 2-butanone. The Villager Bar well is 1500 feet north-northwest of the site in a generally upgradient location. Low concentrations of chloroform (3 µg/L), 1,1,1-trichloroethane (5 µg/L), carbon tetrachloride (7 µg/L), bromoform (8 µg/L), and tetrachloroethene (5 µg/L) are reported for this well. These data suggest that another source or sources of contamination exist upgradient of the site.

Low-level volatile contamination was detected in a cluster of municipal wells located approximately 5000 feet south-southeast of the site (TRW No. 26 through No. 29). Insufficient data on groundwater conditions between these wells and the site make it difficult to determine whether these contaminants are site related.

4.8 Summary

The subsurface materials encountered in the Reich Farm hydrogeologic investigation consist of fill material which overlies coastal plain sediments of the Cohansey and Kirkwood Formations. The fill material is primarily a silty sand and gravel where as the Cohansey and Kirkwood Formations consist of a heterogeneous mixture of sand, silt, clay and gravel which increases in silt and clay content with depth. A silty and clayey zone is present approximately 80 feet below the ground surface which is the contact zone of the two formations.

The occurrence of groundwater beneath the site was investigated and the presence of groundwater flow systems was defined in both the Cohansey and Kirkwood Formations. Both groundwater flow systems investigated in the Cohansey and Kirkwood Formations are hydraulically connected

and under unconfined conditions. A slight downward hydraulic gradient exists between wells screened in the Cohansey Formation and wells screened in the Kirkwood Formation. Groundwater flow direction in the water table aquifer is south with an average hydraulic gradient of 0.003. The calculated average groundwater seepage velocity through the Cohansey Formation beneath the site was calculated to be 93 ft/day (340 feet/year).

Site monitoring well contamination consists primarily of low levels of chlorinated aliphatics. Particular, two monitoring wells, MW5 and MW6, exhibit the majority of this contamination. Well MW5 is located in the former drum storage area, where soils have been determined to be contaminated. Well MW6 is located approximately 200 feet further south, downgradient. The location of these wells and the contaminants detected point to the Reich Farm Site as the source.

Otherwise, contamination detected in residential and municipal wells can not, with available data, be definitively attributed to the site for several reasons. First, available hydrogeologic data indicate that the Villager Bar well (RW-7) lies upgradient of the site. Secondly, much of the contamination detected in the Bouch well is unlike that detected in site soils or other wells.

Finally, many of the detections from Tom's River Municipal well samples were below the detection limits of the instrumentation used for analysis. The influence that these pumping wells may have on other sources of contamination besides the Reich Farm Site is not known.

5.0 ENVIRONMENTAL TRANSPORT AND MIGRATION OF CONTAMINANTS

5.1 Environmental Mobility of Organic Chemicals

Various chemical and physical parameters affect the mobility of organic chemicals in the environment. These parameters include vapor pressure, water solubility, octanol/water partition coefficient (K_{ow}), soil/sediment adsorption coefficient (K_{oc}), and specific gravity. Table 5-1 presents numerical values for these parameters and for the mobility index for the HSL organic chemicals detected at the Reich Farm Site. The mobility index is the logarithmic ratio of three of the preceding parameters: $\log_{10} [(water\ solubility), (vapor\ pressure), \text{ and } (soil\ adsorption\ coefficient)]$. Values presented for K_{ow} and K_{oc} are \log_{10} . A brief discussion of the significance of each of these parameters follows.

Vapor Pressure - The vapor pressure of a chemical compound is directly related to the rate at which it volatilizes (evaporates or sublimates). Verscheuren states that "vapor pressure values provide indications of the tendency of pure substances to vaporize in an unperturbed situation, and thus provide a method for ranking the relative volatilities of chemicals" (Verschueren, 1983).

Water Solubility - The solubility of a chemical is probably the most important factor contributing to groundwater contamination. Lyman states, "Highly soluble chemicals are easily and quickly distributed by the hydrologic cycle. These chemicals tend to have relatively low adsorption coefficients for soils and sediments and relatively low bioconcentration factors in aquatic life" (Lyman, 1982).

Log Octanol/Water Partition Coefficient - This parameter ($\log K_{ow}$) indicates a chemical's tendency to partition between an aqueous and an organic phase and has become increasingly important in environmental fate studies in recent years. The log octanol/water partition coefficient is related to such other parameters as solubility, soil adsorption potential, and bioconcentration factors. Lyman indicates the "values of K_{ow} can be considered to have some meaning in themselves, since they represent the tendency of the chemical to partition itself between an organic phase (e.g., a fish, a soil) and an aqueous phase. Chemicals with low K_{ow} values (e.g., less than 10) may be considered relatively hydrophilic; they tend to have high water solubilities, small sediment/soil adsorption coefficients, and small bioconcentration factors for aquatic life. Conversely, chemicals with high K_{ow} values (e.g., greater than 10^4) are very hydrophobic." Such compounds may be expected to adsorb relatively highly to organic soils and exhibit bioaccumulation tendencies, as well as low water solubility.

TABLE 5-1

MOBILITY PARAMETERS FOR CHEMICALS DETECTED AT THE REICH FARM SITE

PP*	CAS #	Chlorinated Aliphatics	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient	Soil/Sediment Adsorption Coefficient	Specific Gravity (20°C/4°C)	Mobility Index (7)
		Ketones						
	67-64-1	acetone	270 (@ 30°C) (1)	6×10^5	-2.4 (1)	-0.45/1.25 (2)	0.791 (1)	6.9/8.7 Extremely mobile
	78-93-3	2-butanone	78 (1)	3.5×10^5 (1)	0.26 (1)	0.05/1.52 (2)	0.805 (1)	5.9/7.4 Extremely mobile
	591-78-6	2-hexanone	2 (1)	3.5×10^4 (1)	1.38 (1)	1.17/2/13 (2)	0.830 (0°C/4°C) (1)	2.7/3.7 Very mobile
	108-10-1	4-methyl-2-pentanone	6 (1)	1.9×10^4 (1)	1.68 (5)	1/47/2.29 (2)		2.8/3.5 Very mobile
		Monocyclic Aromatics						
(4V)	71-43-2	benzene	76 (1)	1,780 (1)	2.13 (1)	1.92 (3)	0.879 (1)	3.2 Very mobile
(38V)	100-41-4	ethylbenzene	7 (1)	152 (1)	3.15 (1)	2.93 (4)	0.867 (1)	0.10 Very mobile
		total xylenes	6 (1)	180 (1)	3.02 (1)	2.84 (4)	0.870 (1)	0.19 Very mobile
(86V)	108-88-3	toluene	22 (1)	515 (1)	2.69 (1)	2.54 (4)	0.867 (1)	1.5 Very mobile
(7V)	108-90-7	chlorobenzene	8.8 (1)	500 (1)	2.84 (1)	2.64 (4)	1.1066 (1)	1.0 Very mobile
	100-42-5	styrene	5 (1)	300 (1)	2.69 (14)	2.62 (4)	0.9045 (@ 25°C) (1)	0.56 Very mobile
(25B)	95-50-1	1,2-dichlorobenzene	1 (1)	100 (1)	3.38 (1)	3.13 (4)	1.305 (1)	-1.1 Slightly mobile
(65A)	108-95-2	phenol	0.2 (1)	82,000 (@ 15°C) (1)	1.46 (1)	0.94/2.17 (10)	1.070 (1)	2.04/3.27 Very mobile
(64A)	87-86-5	pentachlorophenol	0.001 (1)	14 (1)	5.01 (1)	3.0/4.1 (10)	1.978 (1)	-6.9/-5.9 Immobile
(31A)	120-83-2	2,4-dichlorophenol		4,600 (1)			1.383 (@ 60/25°C) (1)	
	59-50-7	4-chloro-3-methylphenol	1.2×10^{-3} (15)	3,850 (6)	3.10 (1)	3.06 (12)	NA	-2.4 Slightly mobile
		Chlorinated Aliphatics						
(11V)	71-55-6	1,1,1-trichloroethane	100 (1)	4,400 (1)	2.17 (6)	1.76 (8)	1.350 (1)	4.0 Very mobile
(13V)	75-34-3	1,1-dichloroethane	180 (1)	5,500 (1)	1.79 (6)	1.63 (8)	1.174 (1)	4.4 Very mobile
(23V)	67-66-3	chloroform	160 (1)	8,000 (1)	1.97 (1)	1.59 (8)	1.489 (1)	4.5 Very mobile
(85V)	127-18-4	tetrachloroethene	14 (1)	150 (@ 25°C) (1)	2.60 (1)	2.6 (8)	1.626 (1)	0.75 Very mobile
(87V)	79-01-6	trichloroethene	60 (1)	1,100 (@ 25°C) (1)	2.29 (6)	2.09 (8)	1.46 (1)	2.7 Very mobile
(30V)	156-60-5	1,2-dichloroethene (26)	200 (@ 14°C) (1)	600 (1)	1.48 (6)	2.17 (8)	1.260 (1)	2.9 Very mobile
(44V)	75-09-2	methylene chloride	350 (1)	20,000 (1)	1.25 (6)	1.28 (8)	1.327 (7)	5.6 Extremely mobile
(6V)	56-23-5	carbon tetrachloride	90 (1)	800 (1)	2.64 (1)		1.59	
(47V)	75-25-2	bromoform	5.6 (@ 25°C) (1)	3,190 (@ 30°C) (1)	2.30 (6)	1.99 (8)	2.89 (1)	2.3 Very mobile

TABLE 5-1
MOBILITY PARAMETERS FOR CHEMICALS DETECTED AT THE REICH FARM SITE
PAGE TWO

PP*	CAS #	Chemical	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient	Soil/Sediment Adsorption Coefficient	Specific Gravity (20°C/4°C)	Mobility Index (7)	
Phthalate Esters									
(66B)	117-81-7	bis(2-ethylhexyl)phthalate	2.7 x 10 ⁻⁷ (6)	1.3 (6)	8.73 (6)	3.57/6.13 (10)	0.99 (1) (20°C/20°C)	-10	Immobile
(68B)	84-74-2	di-n-butyl phthalate	0.1 (6)	13 (@ 25°C) (6)	5.2 (6)	3.02/4.21 (10)	1.0465 (1)	-4.1/-2.9	Slightly mobile
(70B)	84-66-2	diethyl phthalate	0.05 (@ 70°C)(6)	210 (1)	3.22 (6)	2.01/3.12 (10)	1.12 (1) (25°C/25°C)	-1.5/-0.36	Slightly mobile
(67B)	85-68-7	butylbenzyl phthalate	8.6 x 10 ⁻⁶ (1)	2.9 (1)	4.78 (1)	3.38/3.97 (10)	1.1 (1) (25°C/25°C)	-8.6/-7.9	Immobile
(69B)	117-84-0	di-n-octyl phthalate	60.2	0.285 (1) (24°C)	9.2 (6)	3.38/6.38 (10)	0.99 (1) (20°C/20°C)	-4.1/-1.1	Slightly mobile
Polynuclear Aromatics									
(39B)	206-44-0	fluoranthene	10 ⁻⁶ -10 ⁻⁴ (6)	0.265 (@ 25°C) (1)	5.33 (6)	4.84 (4)	NA	-9.4	Immobile
(84B)	129-00-0	pyrene	6.85 x 10 ⁻⁷ (6)	0.14 (@ 25°C) (1)	5.32 (6)	4.91 (4)	NA	-11.9	Immobile
(72B)	56-55-3	benzo(a)anthracene	5 x 10 ⁻⁹ (6)	0.014 (@ 25°C) (6)	5.61 (6)	5.34 (4)	NA	-15.5	Immobile
(75B)	207-08-9	benzo(k)fluoranthene	9.59 x 10 ⁻¹¹ (6)	0.0016 (@ 25°C) (18)	6.84 (6)	6.22 (4)	NA	-19	Immobile
(20B)	91-58-7	2-chloronaphthalene							
Pesticides/PCBs and Related Compounds									
(103P)	319-85-7	isophorone	0.38 (1)	12,000 (1)	1.7 (6)	1.85 (14)	0.92 (1)	1.8	Very mobile
		BHC (beta)	2.8 x 10 ⁻⁷ (6)	0.70 (6)	3.80 (6)	3.35 (14)	NA	-10	Immobile
(104P)	319-86-8	BHC (delta)	1.7 x 10 ⁻⁵ (6)	17 (@ 24°C) (1)	4.14 (6)	3.29 (14)	1.87 (1)	-6.8	Immobile
(95P)	959-98-8	endosulfan I (alpha)	9 x 10 ⁻³ (6)	0.26 (6)	3.55 (6)	3.56 (14)	NA	-6.2	Immobile
(98P)	72-20-8	endrin	2 x 10 ⁻⁷ (@ 25°C)(1)	0.26 (6)	5.6 (1)	4.06 (14)	NA	-11	Immobile
(89P)	309-99-2	aldrin	2.31 x 10 ⁻⁵ (6)	0.01 (1)	3.01 (16)	4.45 (14)	NA	-11	Immobile
(94P)	74-54-8	4,4'-DDD	10.2x10 ⁻⁷ (@30°C)(6)	0.09 (@ 25°C) (6)	5.99 (6)	4.47 (14)	NA	-12	Immobile
(93P)	72-55-9	4,4'-DDE	6.5 x 10 ⁻⁶ (6)	0.040 (1)	4.28 (1)	3.66 (14)	NA	-10	Immobile
(90P)	60-57-1	dieldrin	1.8 x 10 ⁻⁷ (@25°C)(1)	0.1 (1)	5.6 (13)	4.31 (14)	1.75 (1)	-12	Immobile
(91P))	57-74-9	chlordane	10 ⁻⁵ (@ 25°C) (1)	1.85 (@ 25°C) (6)	2.78 (6)	3.19 (14)	NA	-7.9	Immobile

TABLE 5-1
MOBILITY PARAMETERS FOR CHEMICALS DETECTED AT THE REICH FARM SITE
PAGE THREE

PP*	CAS #	Chemical	Vapor Pressure mm Hg (@ 20°C)	Water Solubility mg/l (@ 20°C)	Octanol/Water Partition Coefficient	Soil/Sediment Adsorption Coefficient	Specific Gravity (20°C/4°C)	Mobility Index (7)
		Pesticides/PCBs and Related Compounds (continued)						
(106P)	53469-21-6	PCB 1242	4.06 x 10 ⁻⁴ (6)	0.10 (@ 25°C) (1)	5.58	3.99 (14)	1.35 (6)	-8.4 Immobile
(110P)	12672-29-6	PCB 1248						
(102P)	319-84-6	BHC (alpha)	2.5 x 10 ⁻⁵ (6)	2.0 (@ 25°C) (6)	3.81 (6)	3.46 (??)	NA	7.8 Immobile
(100P)	74-44-8	heptachlor	3 x 10 ⁻⁴ (@ 25°C) (1)	0.18 (@ 25°C) (6)	5.3 (13)	4.15 (14)	1.57 (1)	-8.4 Immobile
(101P)	1024-57-3	heptachlor epoxide	3 x 10 ⁻⁴ (17)	0.35 (@ 15°C) (6)	5.0 (13)	3.99 (14)	NA	-7.9 Immobile
	108-05-4	vinyl acetate	83 (1)	25,000 (1)			0.932	

Notes:

1. Verschueren
2. Lyman; Eq 4-10 and 4-8 respectively
3. Lyman; Eq 4-10
4. Lyman; Average value Eq 4-6 and 4-10
5. Lyman; fragment analysis Chapter 1. $\log Kow_{MIBK} - \log Kow_{MEK} - f_H + 2f_{CH_3} = f_{CB}$
6. Versar
7. Ford
8. Lyman; Eq 4-7
9. Average values for ortho, meta, and para xylene
10. Lyman; Eq 4-5 and 4-8 respectively
11. Lyman; fragment analysis Chapter 1. $\log Kow_{styrene} = \log Kow (C_9 H_{10}) - f_{CH_3} = f_H$ (p 1-34)
12. Lyman; Eq 4-8
13. Lyman; Eq 2-3
14. Lyman; Eq 4-5 and 4-8, average value
15. Lyman; Eq 14-20
16. Lyman; Example 1-42
17. Assumed similar to heptachlor
18. Lyman; Eq 2-20

Log Soil/Sediment Adsorption Coefficient - This parameter ($\log K_{oc}$) provides an indication of the relative tendency for chemicals to adsorb to organic sediments or soils and thus presents a measure of the mobility of chemicals in the hydrosphere. This parameter is considered most useful in assessing groundwater mobilization of contaminants and in addressing migration because of soil erosion. Lyman indicates that this "parameter has an important bearing on assessments to the fate and transport of chemicals in soils and sediments. K_{oc} is commonly used in river models, runoff models, and soil/groundwater models where the transport of a specific chemical is being investigated." Chemicals with relatively high soil adsorption coefficients are generally immobile in the hydrosphere; but, this same tendency makes them mobile with respect to surface water convection (erosion of contaminated soil or sediment particles).

Specific Gravity - This parameter indicates whether a chemical sinks or floats in water. The environmental significance of this parameter is a matter of debate. Cline indicates that gravimetric stratification of chemicals in the environment is generally not affected by specific gravity unless they are present at levels approaching their saturation concentration (Cline and Viste, 1983). Mackay, on the other hand, indicates that "it is convenient to consider organic liquids less dense than water as 'floaters', which spread across the water table, and organic liquids more dense than water as 'sinkers', which may plummet through sand and gravel to the underlying aquitard, where present" (ES&T, 1985).

Mobility Index - This parameter, presented by Ford and Gurba, is the logarithmic ratio of three of the preceding parameters: $\log_{10} [(water\ solubility), (vapor\ pressure), \text{ and } (soil\ adsorption\ coefficient)]$. It is most useful for surface water contamination, and has been found to be of some use in assessing groundwater migration potential.

Literature values for the above parameters have been presented when available. In some cases, parameters were calculated using empirical regression equations determined using experimental results for similarly structured compounds. Since the parameters used are only qualitative indicators of relative mobility, quantitative precision is not considered to be extremely important. For quantitative purposes, experimentally determined compound and site-specific values are necessary.

The chemicals presented in Table 5-1 are subdivided into general classes and are listed in order of descending environmental mobility: ketones > chlorinated aliphatics > monocyclic aromatics > phthalate esters > pesticides/PCBs. The first three of these classes include constituents of the volatile (purgeable) and acid extractable fractions of the organic HSL. The latter two include

constituents of the base/neutral extractable and pesticide/PCB fractions. The environmental behavior of the volatile/acid extractable fractions is markedly different from the base/neutral extractable/pesticide/PCB fractions.

Ketones, chlorinated aliphatics, and monocyclic aromatics generally have higher water solubilities and vapor pressures than the phthalate esters, and pesticides/PCBs. This makes the volatiles and acid extractables more susceptible to hydrogeologic (groundwater) and atmospheric transport. Compounds in these classes volatilize more readily if present in surface soil or surface water. Their relatively high water solubilities make them prone to leaching by infiltrating precipitation and subject to groundwater transport (advection). The base/neutral extractable and pesticide/PCB fractions, on the other hand, are relatively water insoluble and have lower vapor pressures. These characteristics are reflected by their relatively high soil/sediment adsorption coefficients. These substances are not as susceptible to volatilization or to groundwater transport. They tend to adsorb to surface or subsurface soil. If spills of these substances occur, the primary mechanism by which they may be transported is convection of particulates with surface water runoff.

5.2 Migration of Contaminants

5.2.1 Migration of Soil Contaminant

Site soils, both surface and subsurface, have been contaminated by the waste disposal practices discussed in Section 1.0. The details of site surface soil contamination and subsurface soil contamination are presented in Section 3.5. Figure 3-3 illustrates the extent of organic soil contamination by various compounds. Levels of metals and trace elements detected in soil samples and the site history do not indicate an inorganic contamination problem.

The extent to which organic soil contaminants migrate from the site is controlled largely by the chemical and physical parameters discussed in Section 5.1. In general, the more water soluble volatile chemicals either volatilize to the air, solubilize in surface runoff, or leach to the groundwater table.

Surface runoff is not a potential transport route at the Reich Farm Site: the nearest stream or runoff channel is approximately 3/4 mile downslope of the site, the surface gradient is minimal, and the surface soil permeability is too high for overland flow to be a contributing factor. Precipitation is likely to either infiltrate into the ground or evaporate.

The presence of volatile organics from 0 to 2 feet indicates that volatilization of surface soil contaminants is a potential contaminant transport route. During field activities, organic vapors were not detected from locations other than boreholes. However, shallow digging or test pitting efforts can be expected to release soil bound volatiles.

Volatile compounds disposed in the subsurface or leached from the surface into the subsurface can be bound to the subsurface soil to only a limited degree because of their low soil/sediment adsorption coefficients and higher vapor pressures and water solubilities. Above the water table, volatile compounds in the subsurface will preferentially partition themselves into percolating water rather than to organic and inorganic soil particles. Volatiles leached from subsurface soils will be carried downward to the water table and be advected away from the site. Other compounds such as phthalate esters, PCBs, and pesticides, with higher soil adsorption coefficients, and corresponding lower vapor pressures and water solubilities are more likely to remain bound to site soils and be less mobile. This phenomenon is demonstrated in the site soil borings where generally the phthalate esters are found at higher concentrations than the volatile compounds. This is true except for SB4 where monocyclic aromatics were detected at high concentrations throughout the soil column. The low-permeability clay at the base of this boring may be impeding water movement through the vadose zone and may also be adsorbing these compounds, which are subsequently volatilizing into the soil column above.

The physical movement of surface soil particles is a potential transport mechanism. Soils at the surface (0-2 feet) were sampled in three locations. Each sample exhibited contamination; with two samples exhibiting aromatic hydrocarbons (toluene, xylenes, chlorobenzene, ethylbenzene) and one sample exhibiting halogenated aliphatics (1,1,1-trichloroethane, and tetrachloroethene). Considering the current use of the site, it is possible that leakage from vehicular fuel tanks is a source of the aromatic hydrocarbons. No current, known activity at the site explains the presence of the halogenated aliphatics near the surface. Volatilization from volatile contaminants occurring at depth (below 2 feet) may also contaminate the near surface soil (above 2 feet). More extensive surface soil sampling is needed to confirm the extent of contamination at the surface, and possibly determine the source.

5.2.2 Groundwater Migration

The extent of groundwater contamination in the vicinity of the Reich Farm Site is evidence of the mobility of the site contaminants in the local subsurface environment. The volatile organics are the most mobile of the contaminants in the subsurface, primarily because of their ability to dissolve in

water. Chemical analytical results show that volatiles are found more frequently and at the highest concentrations in the subsurface soils at the site (See Table 3-1). Because of their prevalence and inherent mobility, their occurrence is used to assess the extent of migration from the sources on the site. The migration of base/neutral extractable compounds and other compounds in the subsurface in relation to their occurrence is discussed later in this section.

Based on the observed distribution of contaminants in groundwater at the Reich Farm Site, contaminants are entering the water table beneath the zone of contaminated soils and migrating to the south-southwest in the direction of the hydraulic gradient. The distribution of groundwater contaminants at the site is shown in Figures 4-7 and 4-8. Concentrations at MW5 are the maximum levels recorded in any onsite or offsite well sampled during the RI. MW5 exhibits relatively low concentrations. The sum of reported volatile organics equals 98 µg/l. Only halogenated aliphatic compounds are observed at MW5. One hundred fifty (150) feet directly downgradient of MW5, monitoring well MW6, exhibits 76 µg/l total volatile organics. All compounds found in MW5 also occur in MW6, but at lower or nearly equal concentrations. Only the most mobile, water-soluble site contaminants occur in these wells. Very little of the aromatic hydrocarbons (toluene at 3 µg/l in MW6) predominant in the contaminated soil borings appear in the groundwater samples. Monitoring well MW4 which is located 275 feet downgradient from MW5 and 165 feet west of MW6, demonstrates 1,1,1-trichloroethane only, at 7 µg/l. Monitoring well MW3, located 165 feet east of MW6, exhibits no volatile organics. Three hundred and fifty (350) feet downgradient of MW6, in well MW8, the concentration of 1,1,1-trichloroethane (the only contaminant present) decreases to 6 µg/l. The decreased downgradient concentration indicates either (1) the contaminant solute is dispersing because of mechanical mixing as it is transported by groundwater, causing a reduction in solute concentration over distance, or (2) the potential contaminant plume is narrow and the more concentrated portion passes east of MW8. A curve in the groundwater flow direction is coincident with a change in hydraulic gradient south of MW6, which probably results from a decrease in permeability in the Cohansey aquifer. In any case, the process of dispersion will continue to decrease the solute concentration in the downgradient direction.

Low-level volatile contamination detected in municipal well-field wells, located approximately 5,000 feet from the site, is consistent with contamination detected at the site. However, this contamination cannot be definitively attributed to the site for two reasons: (1) groundwater flow conditions have not been well-defined in the well-field area, and (2) the extensive pumping of these wells influences a large area and the possibility of extraneous sources cannot be ruled out.

A case for extraneous sources is provided by the detection of contamination in residential wells RW-7 and RW-3. RW-7, the Villager Bar well, is hydraulically upgradient of the Reich Farm Site and exhibits contamination that is only partially consistent with that found in site soils and in downgradient monitoring wells. RW-3, the Bouch well, is hydraulically downgradient of the site, but exhibits mostly semi-volatile contamination, quite unlike any found in site soils or other groundwater samples.

Base/neutral extractable organics and pesticides/PCBs are less mobile in the subsurface than the volatiles. These compounds are less water soluble and more likely to adsorb to soils. As presented in Section 3.5, PCBs were detected in two soil samples, at low concentrations in soil borings. Unlike the volatiles, PCB migration in the subsurface is very limited and is not apparent at the Reich Farm Site. The occurrence of phthalate esters exemplifies the subsurface migration capabilities of base/neutral extractable organics. These compounds are more water soluble and less soil adsorptive than the PCBs, but less water soluble and more soil adsorptive than the volatiles. Phthalate esters were detected in trace amounts (up to 10 ppb) in downgradient wells MW3, MW7, and MW9. In soils, phthalates esters are widespread and occur up to 160 ppm. Similarly, pesticides occur in soils at low concentrations, but do not appear in groundwater samples. The movement of the base/neutrals and the pesticides/PCBs in the subsurface is evidently retarded by their adsorption onto soil particles.

6.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

6.1 Introduction

This section presents the health risk and environmental assessment of the Reich Farm Site. The objective of this assessment is to define the actual or potential risks to human health and the environment from the presence of hazardous constituents on and around the site.

For a health or environmental risk to occur several factors must be present: (1) contaminants with toxic characteristics in environmental media, (2) actual or potential exposure pathways, and (3) human or environmental receptors in the exposure pathways. In summary, risk is a function of toxicity and exposure. This assessment estimates the potential for human health and environmental risks at the site by combining information on the toxicity of the compounds detected in environmental media and a site-specific determination of exposure probability. The risk assessment presented in the subsequent sections consists of four components: (1) Hazard Identification, (2) Dose-Response Evaluation, (3) Exposure Assessment, and (4) an estimate of the actual or potential risks or Risk Characterization.

6.2 Hazard Identification

6.2.1 Selection of Indicator Compounds

The purpose of this section is to identify hazardous constituents detected at the site that pose a potential for adverse effects to human and environmental receptors.

Table 6-1 summarizes the occurrence and distribution of HSL organic and inorganic chemicals detected during sampling and analysis of environmental media. Included are the concentration ranges and the frequency of occurrence for each of the chemicals identified. The table was compiled using analytical data obtained during the Remedial Investigation (RI). The complete analytical data base has not been validated by quality assurance personnel as to the performance of the EPA Contract Laboratory.

A review of Table 6-1 indicates that HSL organic and inorganic constituents were detected in environmental media. A screening process is performed to select site-specific indicator compounds and subsequently focus the assessment on the selected contaminants. The indicator compounds address the potential public health and environmental concerns associated with the site. Indicator

TABLE 6-1

**OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE**

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Volatiles (µg/l)</u>									
acetone	2/11	18.9	18-190	--	--	--	--	--	--
2-butanone	2/11	32.6	39-320	4/10	2.7	3-14	2/9	2	5-13
4-methyl-2-pentanone	--	--	--	1/10	0.2	2	--	--	--
2-hexanone	--	--	--	--	--	--	--	--	--
carbon tetrachloride	--	--	--	--	--	--	1/9	0.8	7
1,1-dichloroethane	2/11	0.3	1-2	--	--	--	--	--	--
methylene chloride	--	--	--	--	--	--	--	--	--
tetrachloroethene	2/11	0.9	3-7	1/10	0.1	1	2/9	0.7	1-5
1,1,1-trichloroethane	4/11	13.3	6-78	--	--	--	1/9	0.6	5
trichloroethene	2/11	1.5	8-9	3/10	0.5	1-2.3	--	--	--
trans-1,2-dichloroethene	2/11	0.7	3-5	--	--	--	--	--	--
chloroform	--	--	--	--	--	--	1/9	0.3	3
toluene	1/11	0.3	3	1/10	0.1	1	--	--	--
ethylbenzene	--	--	--	--	--	--	--	--	--
styrene	--	--	--	--	--	--	--	--	--
total xylenes	--	--	--	--	--	--	--	--	--
benzene	--	--	--	1/10	0.1	1	--	--	--
chlorobenzene	--	--	--	--	--	--	--	--	--
bromoform	--	--	--	--	--	--	1/9	0.9	8
cis-1,3-dichloropropene	--	--	--	--	--	--	--	--	--

TABLE 6-1
 OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
 REICH FARM SITE
 PAGE TWO

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Acid Extractables (µg/l)</u>									
phenol	--	--	--	--	--	--	--	--	--
pentachlorophenol	--	--	--	--	--	--	1/9	6.0	54
2,4-dichlorophenol	--	--	--	--	--	--	1/9	6.0	54
4-chloro-3-methylphenol	--	--	--	--	--	--	1/9	5.1	46
<u>Base/Neutral Extractables (µg/l)</u>									
bis(2-ethylhexyl)phthalate	4/11	2.1	4-10	--	--	--	--	--	--
di-n-octyl phthalate	1/11	0.4	4	--	--	--	--	--	--
di-n-butyl phthalate	--	--	--	1/10	0.6	6	--	--	--
diethyl phthalate	--	--	--	--	--	--	--	--	--
butylbenzyl phthalate	--	--	--	--	--	--	--	--	--
benzo(k)fluoranthene	--	--	--	--	--	--	1/9	4.4	40
benzo(a)anthracene	--	--	--	--	--	--	--	--	--
fluoranthene	--	--	--	--	--	--	1/9	6.4	58
pyrene	--	--	--	--	--	--	--	--	--
2-chloronaphthalene	--	--	--	--	--	--	1/9	13	120
isophorone	--	--	--	--	--	--	1/9	6.4	58
1,2-dichlorobenzene	--	--	--	--	--	--	--	--	--
n-nitrosodi-n-propylamine	--	--	--	--	--	--	1/9	13	120
n-nitrosodiphenylamine	1/11	0.5	6	1/10	0.8	8	--	--	--

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE THREE

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Pesticides/PCBs (µg/l)</u>									
BHC	--	--	--	--	--	--	--	--	--
heptachlor epoxide	--	--	--	--	--	--	1/9	2.4	22
heptachlor	--	--	--	--	--	--	--	--	--
endrin	--	--	--	--	--	--	1/9	0.03	0.28
aldrin	--	--	--	--	--	--	--	--	--
dieldrin	--	--	--	--	--	--	1/9	1.6	14
endosulfan I	--	--	--	--	--	--	--	--	--
chlordane	--	--	--	--	--	--	--	--	--
4,4'-DDE	--	--	--	--	--	--	--	--	--
4,4'-DDD	--	--	--	--	--	--	1/9	0.05	0.42
PCB-1242	--	--	--	--	--	--	--	--	--
PCB-1248	--	--	--	--	--	--	--	--	--
<u>Inorganics (µg/l)</u>									
aluminum	11/11	230	78-903	7/10	218	57-783	7/7	126	59-191
barium	3/11	11.3	39-44	7/10	33	32-80	3/7	20	40-55
beryllium	--	--	--	--	--	--	1/7	0.29	2.0
cadmium	2/11	1	5.0-6.0	--	--	--	1/7	39	273
calcium	11/11	7,690	3,070-16,500	5/10	1,519	2,430-4,230	7/7	2,477	756-5,070
chromium	1/11	1.6	18	--	--	--	--	--	--
cobalt	--	--	--	2/10	1.5	4-11	--	--	--
copper	8/11	32.4	12-127	6/10	9	5-23	6/7	79	23-190

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE FOUR

Contaminant	Monitoring Wells			Municipal Wells			Residential Wells		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Inorganics (µg/l)</u> <u>(continued)</u>									
iron	11/11	3,023	324-23,400	7/10	27	16-1,648	7/7	325	70-1,290
lead	7/11	14	9.9-56	2/10	6.9	11-58	4/7	14	8.4-23
magnesium	11/11	185	564-2,770	5/10	956	966-2,590	7/7	2,251	1,520-3,250
manganese	11/11	107.6	23-262	5/10	8	14-22	7/7	21	5-55
mercury	11/11	0.4	0.3-0.6	4/10	0.14	0.1-0.7	2/7	0.1	0.2-0.5
nickel	2/11	3.6	19-21	1/10	2.1	21	1/7	12	86
potassium	11/11	3,953	671-6,950	5/10	1,131	1,870-3,200	7/7	2,164	1,080-3,370
selenium	--	--	--	--	--	--	1/7	0.19	1.3
silver	--	--	--	--	--	--	--	--	--
sodium	11/11	13,400	5,440-41,800	10/10	8,828	2,762-18,500	7/7	8,684	5,830-16,200
tin	--	--	--	--	--	--	1/7	8	58
vanadium	1/11	1.1	12	1/10	1.3	13	1/7	1.7	12
zinc	11/11	850.6	21-5,350	6/10	11.6	7-40	5/7	322	70-1,800

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE FIVE

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Volatiles (µg/kg)</u>						
acetone	18/74	170	5-12,000	3/5	8	9-17
2-butanone	16/74	832	3-31,000	4/5	7.4	8-11
4-methyl-2-pentanone	4/74	1.3	5-47	--	--	--
2-hexanone	3/74	1.2	10-45	--	--	--
carbon tetrachloride	--	--	--	--	--	--
1,1-dichloroethane	--	--	--	--	--	--
methylene chloride	3/74	18	15-1,300	--	--	--
tetrachloroethene	4/74	76	1-5,500	4/5	8	1-22
1,1,1-trichloroethane	2/74	0.3	3-17	1/5	1	7
trichloroethene	5/74	0.01	1	--	--	--
trans-1,2-dichloroethene	--	--	--	1/5	0.2	1
chloroform	--	--	--	--	--	--
toluene	14/74	13	1-810	3/5	25	8-99
ethylbenzene	7/74	120	3-6,100	3/5	18	2-59
styrene	3/74	1,247	250-68,000	--	--	--
total xylenes	8/74	29	2-1,600	3/5	55	26-180
benzene	--	--	--	--	--	--
chlorobenzene	3/74	1	6-27	2/5	34	68-100
bromoform	--	--	--	--	--	--
vinyl acetate	1/74	0.1	1	--	--	--

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE SIX

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Acid Extractables (µg/kg)</u>						
phenol	1/74	90.5	6,700	--	--	--
pentachlorophenol	--	--	--	--	--	--
2,4-dichlorophenol	--	--	--	--	--	--
4-chloro-3-methylphenol	--	--	--	--	--	--
<u>Base/Neutral Extractables (µg/kg)</u>						
bis(2-ethylhexyl)phthalate	17/74	2,403	37-160,000	5/5	2,448	400-5,700
di-n-octyl phthalate	3/74	29	67-1,900	1/5	114	570
di-n-butyl phthalate	10/74	11	34-240	4/5	53	71-110
diethyl phthalate	1/74	0.2	17	--	--	--
butylbenzyl phthalate	2/74	72	1,000-4,300	2/5	154	350-420
benzo(k)fluoranthene	--	--	--	--	--	--
benzo(a)anthracene	1/74	0.5	34	--	--	--
fluoranthene	1/74	0.5	37	1/5	36	180
pyrene	2/74	1	37	1/5	22	110
2-chloronaphthalene	--	--	--	--	--	--
isophorone	--	--	--	--	--	--
1,2-dichlorobenzene	2/74	7	220-310	--	--	--

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE SEVEN

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Pesticides/PCBs (µg/kg)</u>						
BHC	20/74	5.3	1.6-100	--	--	--
heptachlor epoxide	2/74	0.3	1.5-24	--	--	--
heptachlor	1/74	0.02	1.4	--	--	--
endrin	3/74	0.4	8.85	--	--	--
aldrin	2/74	0.05	2.6	1/5	1	7.2
dieldrin	1/74	0.05	3.6	--	--	--
endosulfan I	1/74	0.02	1.4	--	--	--
chlordane	1/74	0.5	38	--	--	--
4,4'-DDE	3/74	0.2	9	--	--	--
4,4'-DDD	1/74	0.05	3.7	--	--	--
aroclor-1242	1/74	3	210	--	--	--
aroclor-1248	1/74	7	510	--	--	--
<u>Inorganics (mg/kg)</u>						
aluminum	80/80	1,312	23-4,478	5/5	3,742	3,149-4,262
barium	80/80	7	1-80	5/5	12	9-16
beryllium	59/80	0.2	0.1-0.4	3/5	0.06	0.01
cadmium	--	--	--	--	--	--
calcium	77/80	1,191	17-28,250	5/5	884	403-1,850
chromium	78/80	7	1-46	5/5	4.2	2-6
cobalt	77/80	1.2	1-11	5/5	1.4	1-2
copper	62/80	2.6	1-23	5/5	5.2	6-20

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF HSL ORGANICS AND INORGANICS
REICH FARM SITE
PAGE EIGHT

Contaminant	Subsurface Soil Samples			Surface Soil Samples		
	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range	No. of Occurrences/ No. of Samples	Average Concentration	Concentration Range
<u>Inorganics (mg/kg)</u> <u>(continued)</u>						
iron	79/80	3,005	16-14,636	5/5	4,364	3,797-5,062
lead	26/80	3.1	3-61	5/5	11.2	6.9-15
magnesium	76/80	349	10-8,757	5/5	212	152-241
manganese	78/80	10	1-35	5/5	15.6	9-31
mercury	9/80	0.03	0.1-0.6	--	--	--
nickel	1/80	0.3	21	--	--	--
potassium	48/80	821	357-4,452	--	--	--
selenium	--	--	--	--	--	--
silver	37/80	1.8	2.1-7.0	--	--	--
sodium	52/80	464	12-9,313	2/5	206	506-526
tin	--	--	--	--	--	--
vanadium	75/80	8.0	1.1-33.4	5/5	6.0	4.7-7.6
zinc	67/80	6.0	1-44	5/5	8.4	2-17

Notes: (--) - Indicates compound not detected above detection limits.

compounds (contaminants of concern) are assumed to represent the most toxic, mobile, and/or persistent contaminants at the site as well as those detected at the highest concentrations.

The following factors are considered in the selection of indicator compounds.

- The concentrations of the contaminants detected, the frequency of detection, the extent of contamination in the various environmental media sampled, and the presence/absence of the compound in media presenting the greatest opportunities for human and environmental exposure.
- Physical and chemical characteristics of the contaminants, and their environmental fate and mobility in the environment, i.e., whether the compound will readily volatilize to the air or be transported via advection or diffusion in soil and groundwater or whether the compound is persistent in the environment.
- Toxicological properties of the contaminants including carcinogenicity, mutagenicity, teratogenicity, reproductive toxicity, and acute and chronic systemic toxicity. Also considered is the potential for bioconcentration and bioaccumulation, and whether the concentration of the contaminant exceeds relevant regulatory standards and criteria.

Indicator compounds selected to evaluate health and environmental risks are presented in Table 6-2. The rationale for selection is discussed below.

6.2.1.1 Volatile Organic Indicator Compounds

Twenty-two volatile organic compounds (VOCs) were detected in environmental media sampled during the RI. The major chemical classes detected include ketones, monocyclic aromatic hydrocarbons, and chlorinated aliphatic hydrocarbons. VOCs were found in virtually all environmental media sampled including surface soil, subsurface soil, and groundwater. These compounds are mobile in the environment and will readily volatilize to the ambient air and/or migrate from contaminated soil to groundwater. In view of the environmental mobility of these

TABLE 6-2
INDICATOR COMPOUNDS
REICH FARM SITE

Volatile Organics

acetone	1,1,1-trichloroethane
2-butanone	trichloroethene
4-methyl-2-pentanone	benzene
carbon tetrachloride	ethylbenzene
chloroform	toluene
methylene chloride	styrene
1,1-dichloroethane	xylene
trans-1,2-dichloroethene	chlorobenzene
tetrachloroethene	

Semi-Volatile Organics

Acid Extractables

pentachlorophenol	4-chloro-3-methylphenol
2,4-dichlorophenol	

Base/Neutral Extractables

bis(2-ethylhexyl)phthalate	fluoranthene
di-n-octyl phthalate	pyrene
di-n-butyl phthalate	1,2-dichlorobenzene
diethyl phthalate	isophorone
butylbenzyl phthalate	n-nitrosodiphenylamine
benzo(k) fluoranthene	n-nitrosodi-n-propylamine
benzo(a)anthracene	

TABLE 6-2
INDICATOR COMPOUNDS
REICH FARM SITE
PAGE TWO

Pesticides/PCBs

heptachlor epoxide	4,4'-DDD
dieldrin	PCB-1242
endrin	PCB-1254

Inorganics

cadmium	lead
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chemicals, and the frequency of detection in the environment, virtually all of the VOCs detected have been retained as indicator chemicals. These include the following:

- acetone
- 2-butanone (methyl ethyl ketone)
- 4-methyl-2-pentanone (methyl isobutyl ketone)
- chloroform
- carbon tetrachloride
- methylene chloride
- 1,1-dichloroethane
- trans-1,2-dichloroethene
- tetrachloroethene
- 1,1,1-trichloroethane
- trichloroethene
- benzene
- ethylbenzene
- styrene
- toluene
- xylenes
- chlorobenzene

Chloroform, carbon tetrachloride, methylene chloride, tetrachloroethene, trichloroethene, and benzene are known or suspected human and/or animal carcinogens. Inclusion of these contaminants as indicator compounds will address the carcinogenic risk associated with potential human exposure to chemicals identified during the RI. Benzene, chloroform, and carbon tetrachloride were detected only in residential well and/or municipal well samples. The source of these compounds has not been established. However to characterize potential exposures, these compounds have been included as contaminants of concern. The remaining compounds (noncarcinogens) were frequently detected in the media sampled and/or were detected at relatively high concentrations and consequently were retained as indicator contaminants.

VOCs found in environmental media but not selected as indicator compounds include 2-hexanone, bromoform, and vinyl acetate. These compounds were detected at relatively low concentrations and/or relatively infrequently. In addition, the physical, chemical, and toxicological properties of these constituents are similar to those of several of the VOC indicator compounds.

6.2.1.2 Semi-Volatile Indicator Compounds

Acid Extractables

Acid extractable compounds are relatively water soluble and mobile in the environment. These constituents were not detected in surface soils or monitoring well samples obtained downgradient from the site. Phenol was detected in only one subsurface sample at the site (6,700 µg/kg) and consequently has not been retained as an indicator compound. However, three acid extractable compounds (pentachlorophenol, 2,4-dichlorophenol, and 4-chloro-3-methylphenol) were found in one residential well sample (RW-003). These constituents were not detected in the duplicate sample. Although the source of these compounds has not been established, all of these constituents have been retained as indicator compounds because of the potential concern associated with ingestion in drinking water.

Base/Neutral Extractables

In terms of contaminant concentrations and frequency of detection, a large number of base/neutral extractable compounds were detected at the site. Phthalate esters are the principle contaminants.

Five phthalate esters were detected in environmental media at the site. These include (bis(2-ethylhexyl) phthalate, di-n-octyl phthalate, di-n-butyl phthalate, diethyl phthalate, and butylbenzyl phthalate. Bis(2-ethylhexyl)phthalate (BEHP) is carcinogenic in experimental animals and has been classified by the EPA as a probable human carcinogen. BEHP was frequently detected at relatively high concentrations in onsite surface and/or subsurface soil samples and thus has been retained as an indicator compound. Inclusion of the remaining phthalate esters as contaminants of concern would characterize the noncarcinogenic risks associated with this class of compounds.

All of the polycyclic aromatic hydrocarbons (PAHs) (benzo(k)fluoranthene, benzo(a)anthracene, fluoranthene, pyrene, and 2-chloronaphthalene) detected at the site have been selected as contaminants of concern. PAHs are persistent in environmental media and tend to adsorb to soil organic matter. Benzo(a)anthracene, fluoranthene, and pyrene were detected in onsite surface and/or subsurface soil samples. Benzo(k)fluoranthene and 2-chloronaphthalene were detected in one residential well sample (RW-003). These constituents were not detected in the duplicate sample. Because the individual toxicity of these compounds has not been completely assessed, and the behavior of the individual constituents in a mixture of PAHs has not been completely established, all

PAHs have been retained as contaminants of concern. These sources of the PAHs in the residential well sample has not been determined.

Of the remaining base/neutral extractable constituents, 1,2-dichlorobenzene, isophorone, and the nitrosamines (n-nitroso-n-propylamine, n-nitrosodiphenylamine) were selected as contaminants of concern.

2-Chloronaphthalene and isophorone were detected in residential well RW-003. Consequently, they were retained as indicator compounds. The nitrosamines were detected in groundwater, municipal well water, and/or residential well water samples. Both of these compounds are suspected carcinogens. Nitrosamines as a class are associated with liver effects. Consequently, these contaminants were selected as contaminants of concern.

6.2.1.3 Pesticides/Polychlorinated Biphenyls Indicator Compounds

Several pesticides (alpha-BHC, beta-BHC, delta-BHC, heptachlor epoxide, heptachlor, endrin, aldrin, dieldrin, 4,4'-DDE, 4,4'-DDD, endosulfan I, and chlordane) and polychlorinated biphenyls (PCBs) were detected in samples collected at the site.

Pesticides were frequently found in onsite soil samples and at relatively low concentrations. An evaluation of the occurrence and distribution of the compounds and available historical information on wastes previously disposed at the site suggests the site is not a source of pesticide contamination. The presence of these compounds is most likely attributed to the use of pesticides in agricultural applications from farmlands surrounding the site. Consequently, these constituents are not selected as contaminants of concern. However, heptachlor epoxide, dieldrin, endrin, and 4,4'-DDD were detected in residential well sample RW-003. These pesticides were not detected in the duplicate sample. Although the source of these compounds has not been established, these constituents will be considered in the characterization of risk from residential well samples.

PCBs (PCB-1252 and PCB-1248) were detected in two subsurface soil samples collected at the site. Although the potential for exposure to these compounds is low, PCBs are persistent in the environment, are bioaccumulated and biomagnified, and are classified as probable human carcinogens. Consequently, PCBs were retained as indicator compounds.

6.2.1.4 Inorganic Indicator Compounds

Inorganic constituents were detected in all environmental media sampled. Selection of inorganic indicator compounds is based on an evaluation of the occurrence and distribution in environmental media, and a comparison of the observed concentrations to literature background soil concentrations and relevant regulatory standards and guidelines.

A comparison of the concentrations of inorganic constituents detected in onsite surface and subsurface soil samples to U.S. and New Jersey background soil concentrations indicates that none of the contaminants were detected in excess of expected background levels (Stockman, 1986; Shacklette and Boerngen, 1984).

However, lead and cadmium exceed the National Interim Primary Drinking Water Standard Maximum Contaminant Levels (MCLs) of 50 µg/l and 10 µg/l, respectively, in monitoring well, municipal well, and/or residential well samples. Although the site has not been implicated as a source of these compounds, lead and cadmium are selected as contaminants of concern.

6.2.2 Toxicological Evaluation

The purpose of this section is to identify the health and environmental hazards associated with the indicator compounds identified in Section 6.2.1. The indicator compounds represent the greatest public health and environmental concerns associated with the Reich Farm Site.

The toxicological evaluation is the process of characterizing the inherent toxicity of these compounds. It consists of a review of the scientific data to determine the nature and extent of the health and environmental hazards associated with exposure to the various chemicals. The end product is a toxicity profile for each contaminant of concern. These profiles provide the qualitative weight-of-evidence that site associated contaminants pose actual or potential hazards to human health and the environment.

Toxic effects considered in these profiles include:

- Threshold health effects (noncarcinogenic effects) - Effects in which a certain dose is required to result in a particular adverse effect. Toxicological endpoints, routes of exposure, and doses in humans and/or animal studies are provided where appropriate.
- Non-threshold health effects (carcinogenic effects) - Effects to which any exposure could potentially be associated with adverse health implications. Toxicological endpoints, routes of exposure, and doses in humans and/or animal studies are provided.
- Environmental effects - Acute and chronic toxic effects observed in aquatic biota and terrestrial wildlife.

Toxicity profiles for the indicator compounds are presented in Appendix G. A review of these profiles indicates that the indicator compounds are associated with both threshold and non-threshold health effects in humans and/or experimental animals, and toxic effects in aquatic biota and/or terrestrial wildlife. Although it is evident that contaminants detected at the site are associated with adverse health and environmental impacts, dose-response relationships and the potential for human and environmental exposure must be evaluated before the risks to receptors can be determined.

6.3 Dose-Response Evaluation

6.3.1 Health Effects

An important component of the risk assessment process is the determination of the relationship between the dose (amount of compound to which an individual or population is exposed) and the potential for adverse health effects. Dose-response relationships provide a means by which potential public health impacts may be evaluated.

The most applicable information on dose-response relationships are current standards, criteria, and guidelines that provide a quantitative indication of the potency of a compound. Applicable and relevant standards and/or criteria include MCLS, EPA Health Advisories, and Ambient Water Quality Criteria (AWQC). Carcinogenic Potency Factors (CPF) and Acceptable Daily (ADIs) are also included.

Table 6-3 lists the standards, criteria, and guidelines for the indicator compounds selected to evaluate potential public health and environmental risks. A discussion of the assumptions and limitations associated with these parameters follows.

- Carcinogenic Potency Factor - Carcinogenic risks are estimates of the probability, or range of probabilities, that a specific adverse effect will occur. The Carcinogenic Potency Factor (CPF) developed by the EPA Carcinogenic Assessment Group, is defined as the estimated lifetime cancer risk to humans per unit of dose, i.e., the incidence of cancer at a dose of 1 mg/kg of body weight/day for continuous lifetime exposure (Redricks, 1984). Slope factors based on animal data are the 95 percent upper-bound confidence limit of the carcinogenic potency of the chemical estimated from the linear multi-stage model (i.e., the extrapolation of the non-threshold dose-response relationship observed in animals to the linear, non-threshold dose response relationship in humans). Human slopes are point estimates based on the linear non-threshold model. CPFs can be used to convert the estimated dose of a compound to incremental lifetime cancer risk.
- Acceptable Daily Intakes - Acceptable Daily Intakes (ADIs) are the amount of a toxicant (in mg/day for a 70 kg adult) that is not expected to result in adverse health effects (threshold effects) after chronic exposure to the general population (including sensitive subgroups). ADIs are calculated by dividing a quantitative indication of toxicity [i.e., No-Observed Effect Level (NOEL), No-Observed Adverse Effect Level (NOAEL), Lowest-Observed Adverse Effect Level (LOAEL), or Threshold Limit Value (TLV)] derived from human or animal toxicity studies, by an appropriate uncertainty factor. ADIs are used to evaluate the potential for threshold toxic effects associated with exposure to site-related hazardous constituents.
- Maximum Contaminant Levels - National Primary Drinking Water Standard Maximum Contaminant Levels (MCLs), promulgated under the Safe Drinking Water Act, are enforceable standards for contaminants in public drinking water supply systems. MCLs are based on lifetime exposure to a contaminant for a 70-kg adult who consumes 2 liters of water per day. MCLs are calculated to reflect exposure to a contaminant from all sources (air, food, water, etc.). They not only consider health factors, but also the economic and technical feasibility of removing a contaminant from a water supply system. Secondary Drinking Water Standard MCLs are non-enforceable standards that consider the aesthetic quality of drinking water. The EPA has also recently proposed MCLs and Recommended MCLs (RMCLs) for several organic and inorganic compounds in drinking water. Proposed

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Volatiles</u>					
acetone	--	Inhalation - 3.0(2)(3)	--	--	--
2-butanone	--	Oral - 4.6 x 10 ⁻² (4) Inhalation - 0.219(5)	--	1-day (child): 7,500 10-day (child): 750 Longer-term (child): 2,500 Longer-term (adult): 8,500 Lifetime: 860	--
4-methyl-2-pentanone	--	0.104(3)	--	1-day (child): 233 10-day (child): 233	0(0.67)(h)
carbon tetrachloride	1.3x10 ⁻¹	--	0(a) 5(b)	1-day (child): 4,000 10-day (child): 160 Longer-term (child): 71 Longer-term (adult): 250 Lifetime: 25	0(4.2 µg/l)
chloroform	7.0x10 ⁻²	--	--	--	0(0.19)(h)(i)
methylene chloride	1.4x10 ⁻² (7)(1) 7.5x10 ⁻³ (7)(?)	--	--	1-day (child): 13,300 10-day (child): 1,500 Lifetime: 1,750	0(0.19)(h)(i)
1,1-dichloroethane	--	Oral - 0.11(5) Inhalation - 0.14(5)	--	--	--

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE
PAGE TWO

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Volatiles (continued)</u>					
trans-1,2-dichloroethene	--	Oral - 0.027(9) Inhalation - 5.7x10 ⁻³ (9)	--	1-day (child): 2,720 10-day (child): 2,720 Longer-term (child): 1,000 Longer-term (adult): 3,500 Lifetime: 350	--
tetrachloroethene	6.0x10 ⁻²	--	--	10-day (child): 34,000 Longer-term (child): 1,940 Longer-term (adult): 6,800 Lifetime: 680	0(8.8 ng/l)(h)
1,1,1-trichloroethane	--	Oral - 5.4x10 ⁻¹ (6) Inhalation - 6.3(6)	200(a)(b)	1-day (child): 140,000 10-day (child): 35,000 Longer-term (child): 35,000 Longer-term (adult): 125,000 Lifetime: 1,000	19,000
trichloroethene	1.2x10 ⁻²	--	0(a) 5(b)	--	0(2.8)(h)
benzene	2.9x10 ⁻²	--	0(a) 5(b)	1-day (child): 233 10-day (child): 233	0(0.67)(h)
ethylbenzene	--	Oral - 9.7 x 10 ⁻² (7)	680(c)	1-day (child): 21,000 10-day (child): 2,100 Lifetime: 3,400	2,400

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE
PAGE THREE

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Volatiles (continued)</u>					
total xylenes	--	Oral - 0.01(8) Inhalation - 0.4(8)	440(c)	1-day (child): 7,900 Longer-term (child): 7,900 Longer-term (adult): 27,300 Lifetime: 2,200	--
styrene	--	--	1,400(c)	1-day (child): 27,000 10-day (child): 20,000 Longer-term (child): 20,000 Longer-term (adult): 70,000 Lifetime: 7,000	--
chlorobenzene	--	Oral - 0.027(9) Inhalation - 5.7x10 ⁻³ (9)	--	1-day (child): 1,800 10-day (child): 1,800 Longer-term (child): 9,000 Longer-term (adult): 30,000 Lifetime: 3,150	488
toluene	--	Oral - 0.29(10) Inhalation - 1.5(10)	2,000(c)	1-day (child): 18,000 10-day (child): 6,000 Lifetime: 10,800	15,000

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE
PAGE FOUR

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Acid Extractables</u>					
pentachlorophenol	--	Oral - 0.03 ⁽¹¹⁾	--	1-day (child): 1,000 10-day (child): 300 Longer-term (child): 300 Longer-term (adult): 1,050 Lifetime: 1,050	1,010
2,4-dichlorophenol	--	0.1 ⁽³⁾	--	--	3.09 mg/l
4-chloro-3-methylphenol	--	--	--	--	--
<u>Base/Neutral Extractables</u>					
bis(2-ethylhexyl) phthalate	--	0.6 ⁽³⁾	--	--	21,000
di-n-octyl phthalate	--	--	--	--	--
di-n-butyl phthalate	--	1.26 ⁽³⁾	--	--	44,000
diethyl phthalate	--	12.6 ⁽³⁾	--	--	434,000
benzyl butyl phthalate	--	--	--	--	--
benzo(k)fluroanthene	--	--	--	--	0(3.1 ng/l) ^(h)
benzo(a)anthracene	--	--	--	--	0(3.1 ng/l) ^(h)

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE
PAGE FIVE

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Base/Neutral Extractables (continued)</u>					
fluoranthene	--	6.0x10 ⁻³ (3)	--	--	188
pyrene	--	--	--	--	--
isophorone	--	0.16(3)	--	--	5,200
1,2-dichlorobenzene	--	0.09(3)	620(c)	Longer-term (child): 8,930(g) Longer-term (adult): 51,250 Lifetime: 3,125	470
n-nitrosodi-n-propylamine	--	--	--	--	0(1.4 ng/l) ^(h)
n-nitrosodiphenylamine	4.92x10 ⁻³	--	--	--	--
heptachlor epoxide	--	--	0(c)	Lifetime: 1	--
dieldrin	30.4	--	--	--	0(1.1 ng/l)
endrin	--	1x10 ⁻³ (3)	--	1-day (child): 20 10-day (child): 5 Longer-term (child): 4.5 Longer-term (adult): 16	1
4,4'-DDD	--	--	--	--	--

TABLE 6-3
DOSE-RESPONSE EVALUATION
REICH FARM SITE
PAGE SIX

Compound	CPF(1)	ADI (mg/kg-day)	MCL(13)(14)(15) (µg/l)	Health Advisory (16) (µg/l)	AWQC (4)(17)
					Ingestion of Drinking Water (µg/l)
<u>Pesticides/PCBs</u>					
PCBs	4.34	--	--	--	0(0.126)(h)
<u>Inorganics</u>					
cadmium	7.8	Oral - 2.9×10^{-4} (4)	10(d) 5(c)	1-day (child): 43 10-day (child): 8 Longer-term (child): 5 Longer-term (adult): 18 Lifetime: 18	10 µg/l
lead	--	Oral - 1.4×10^{-3} (4) Inhalation - 4.3×10^{-4} (4)	50(d) 20(c)	--	50

Notes:

Sources:

CPF Carcinogenic Potency Factor
ADI Acceptable Daily Intake
MCL Maximum Contaminant Level
AWQC Ambient Water Quality Criteria
I Inhalation
O Oral
(a) Recommended MCL
(b) Proposed MCL
(c) Proposed Recommended MCL
(d) Primary Drinking Water Standard MCL
(g) 1-day and 10-day Health Advisories are the same
as the long-term health advisory
(h) The AWQC for the maximum protection of human
health is zero. The value presented corresponds
to a 10^{-6} estimated lifetime cancer risk
(i) AWQC for halomethanes

(1) USEPA, 1985(d)
(2) USEPA, 1984(c)
(3) USEPA, 1984(b)
(4) ICF, Inc., 1985
(5) USEPA, 1984(e)
(6) USEPA, 1984(l)
(7) USEPA, 1984(e)
(8) USEPA, 1984(m)
(9) USEPA, 1984(d)
(10) USEPA, 1984(k)
(11) USEPA, 1984(j)
(13) USEPA, 1982
(14) USEPA, 1979
(15) USEPA, 1985(b)
(16) USEPA, 1985(a)
(17) USEPA, 1980(a)

MCLs and RMCLs are nonenforceable guidelines proposed in advance of MCL. RMCLs do not consider the technical feasibility of contaminant removal. MCLs, proposed MCLs, and RMCLs are used to estimate the potential for adverse health effects associated with ingestion of contaminated drinking water.

- Health Advisories - Health Advisories are nonenforceable guidelines, developed by the Office of Drinking Water, for chemicals that may be intermittently encountered in public water supply systems. Short-term Health Advisories are calculated for a 10 kg child (1 year old infant) who ingests 1 liter of water per day for two exposure levels: 1-day, and 10-days. Lifetime Health Advisories are calculated for a 70 kg adult assumed to drink 2 liters of water per day. Longer Health Advisories (1 to 2 years) are calculated for both a 10 kg child and a 70 kg adult. These guidelines do not consider carcinogenic risks or synergistic effects. Health Advisories are used to evaluate the potential for acute and chronic health effects (threshold) associated with ingestion of contaminated drinking water.
- Ambient Water Quality Criteria - Ambient Water Quality Criteria (AWQC) are nonenforceable guidelines for the protection of human health from exposure to contaminants in ambient water. These criteria are estimates of the concentration that will not result in adverse health effects in humans, and for known or suspected carcinogens, the concentrations associated with incremental lifetime cancer risks of 10^{-4} (one additional case of cancer in 10,000 people exposed) through 10^{-7} (one additional case of cancer in 10,000,000 people exposed). AWQC have been used by many states to develop enforceable ambient water quality standards. The AWQC tabulated in Table 6-3 are adjusted for the ingestion of drinking water only and assume a 70-kg adult 2 liters of water per day over a 70-year lifetime. These criteria are used to evaluate the potential for threshold and carcinogenic health risks associated with exposure to contaminants in drinking water.

6.4 Exposure Assessment

6.4.1 Introduction

The purpose of this section is to evaluate the potential for human and environmental exposure to hazardous constituents associated with the Reich Farm Site. This section identifies actual or potential routes of exposure, characterizes the populations exposed, and evaluates the degree or magnitude of exposure.

To determine if exposure might occur, at present or in the future, and the most likely pathways of chemical release and transport, and the human and environmental activity patterns near the site must be defined. A complete exposure pathway has four necessary components: (1) a source of chemical release to the environment, (2) a route of contaminant transport through an environmental medium, (3) an exposure or contact point, and (4) the presence of a human or environmental receptor at the exposure or contact point. These components are addressed in the following subsections. In the final subsection, quantitative estimates of potential exposure levels are provided for each route of exposure at the site.

6.4.2 Source of Contamination and Routes of Contaminant Transport

The site includes approximately 3 acres located in the Pleasant Plains section of Toms River, New Jersey. Historical records indicate a variety of drummed wastes were stored and/or disposed at the site. In addition, waste materials were also discharged directly into a number of excavated trenches. Drummed wastes and contaminated soil (to a maximum depth of 16 feet) were removed from the site in 1972 and 1974. For the purpose of this assessment, residual wastes/contaminants present in environmental media represent the primary source of contamination at the site.

Waste materials previously stored/disposed onsite include organic wash solvents, still bottoms, and residues from the manufacture of chemicals, plastics, and resins. Potential hazardous constituents present in the wastes include aromatic hydrocarbons, phenols, halogenated aliphatic hydrocarbons, and phthalate esters.

Sampling and analysis of environmental media during the RI indicated the presence of HSL organic and inorganic constituents. The occurrence and distribution of these contaminants was discussed in detail in Sections 3.0 and 4.0. A review of Sections 3.0 and 4.0 and Table 6-1 (contaminant occurrence and distribution summary) indicates that indicator compounds were detected in onsite surface soils, onsite subsurface soils, and groundwater. A summary of the occurrence and distribution of hazardous constituents in environmental media follows:

- Surface Soils - Constituents detected in onsite surface soil include relatively low concentrations of ketones, chlorinated aliphatic hydrocarbons, aromatic hydrocarbons, phthalate esters, and polycyclic aromatic hydrocarbons. These compounds were detected in samples from the former drum storage area. Remaining portions of the site were not sampled.

- Subsurface Soils - Subsurface soil samples contained comparatively higher concentrations of HSL organics. Contaminants detected include primarily ketones, chlorinated aliphatic hydrocarbons, aromatic hydrocarbons, and phthalate esters. Relatively low concentrations of several pesticides and PCBs were detected in subsurface soil samples. HSL organic constituents were detected in both backfill soil from previous excavations and in geologic strata below the backfill.
- Groundwater (monitoring wells) - HSL organic constituents detected in downgradient monitoring wells include chlorinated aliphatic hydrocarbons, ketones, and phthalate esters. The highest concentrations of contaminants were detected in monitoring wells immediately downgradient from the source. Fewer contaminants, at lower concentrations, were detected in wells installed further downgradient. Acetone and 2-butanone were detected in monitoring wells located upgradient of the site.
- Groundwater (residential wells and municipal wells) - HSL organic and inorganic constituents were detected in residential wells and/or municipal wells screened in both the Cohansey and Kirkwood Formations. Constituents were detected in both upgradient and downgradient locations. Most of the detections were below the CLP detection limits. The source of these compounds has not been established. Insufficient data are available to determine if these compounds are site related.

The distribution of hazardous constituents in samples collected during the RI indicates that migration through environmental media is occurring. Chemical and physical characteristics that affect the fate and mobility of the indicator compounds are discussed in Section 5.0. A characterization of the potential for contaminant release and transport was also included. Table 6-4 summarizes the major environmental fate and transport processes for the contaminants of concern. A summary of the major routes of contaminant transport to human and environmental receptors is provided below. Contaminant transport pathways include:

- Contaminant Transport Via the Movement of Groundwater Underlying the Site - Infiltration of precipitation into waste materials and contaminated soil has contaminated groundwater underlying the site. Contaminants have been detected in groundwater downgradient of the site. Alterations in the hydraulic gradient due to localized pumping influences may also affect the migration of site-associated contaminants, although insufficient data preclude definitive conclusions.

TABLE 6-4

**SUMMARY OF ENVIRONMENTAL FATE AND TRANSPORT MECHANISMS
REICH FARM SITE**

Chemical Class	Environmental Fate and Transport Mechanisms ⁽¹⁾⁽²⁾⁽³⁾	Transport in Environmental Media ⁽¹⁾⁽²⁾⁽³⁾
Ketones ^(a)	<ul style="list-style-type: none"> • Volatilization • Photooxidation • Not adsorbed to soil organic matter • Biodegradation (predominant fate mechanism) 	<ul style="list-style-type: none"> • Does not adsorb to soil • Very mobile in groundwater • Will volatilize from soils to the ambient air
Monocyclic Aromatic Hydrocarbons ^(b)	<ul style="list-style-type: none"> • Volatilization • Bioaccumulation may be a significant fate process for chlorinated benzenes and pentachlorophenol • Moderate biodegradation 	<ul style="list-style-type: none"> • Some constituents may slightly adsorb to soil • Mobile in groundwater • Will readily volatilize from soils to the ambient air
Chlorinated Aliphatics ^(c)	<ul style="list-style-type: none"> • Volatilization • Will not readily adsorb to soil organic matter • Biodegradation/biotransformation are insignificant fate processes 	<ul style="list-style-type: none"> • Does not adsorb to soil • Very mobile in groundwater • Will readily volatilize to the ambient air
Phthalate Esters ^(d)	<ul style="list-style-type: none"> • Adsorbed to soil organic matter • bioaccumulation • Biotransformation/biodegradation are significant fate processes 	<ul style="list-style-type: none"> • Readily adsorbed to organic matter in soils. Transported via surface water runoff or sediment transport • Generally not mobile in groundwater • Will not volatilize to air but may be transported via airborne particulate soil or dust
Polycyclic Aromatic Hydrocarbons ^(e)	<ul style="list-style-type: none"> • Absorbed to soil organic matter • Photolysis/oxidation • Biotransformation/biodegradation 	<ul style="list-style-type: none"> • Readily absorbed to soil. Transported via surface water runoff or sediment transport. • Not mobile on groundwater. • Transported in air via airborne particulate soils or dust.
Nitrosamines ^(f)	<ul style="list-style-type: none"> • Neither volatilization or adsorption are significant processes • Photolysis • Biotransformation/Biodegradation 	<ul style="list-style-type: none"> • Mobile in groundwater

TABLE 6-4
SUMMARY OF ENVIRONMENTAL FATE AND TRANSPORT MECHANISMS
REICH FARM SITE
PAGE TWO

Chemical Class	Environmental Fate and Transport Mechanisms ⁽¹⁾⁽²⁾⁽³⁾	Transport in Environmental Media ⁽¹⁾⁽²⁾⁽³⁾
PCBs ^(g)	<ul style="list-style-type: none"> • Adsorption to soil organic matter • Bioaccumulation 	<ul style="list-style-type: none"> • Absorbed to soil. Transported via surface water runoff or transport of sediments. • Generally not mobile in groundwater.
Pesticides ^(h)	<ul style="list-style-type: none"> • Adsorption to soil organic matter • Bioaccumulation • Biotransformation/Biodegradation 	<ul style="list-style-type: none"> • Adsorbed to organic matter in soils. • Will not readily volatilize to air but may be transported via airborne particulate soil or dust.
Inorganics ⁽ⁱ⁾	<ul style="list-style-type: none"> • Chemical speciation • Adsorption to soil organic matter • Bioaccumulation • Biotransformation(lead, mercury) 	<ul style="list-style-type: none"> • Absorbed to organic matter in soil. • Mobile in groundwater if present in an acidic environment. • Volatilization not significant. Transported in air via airborne particulate soils or dusts.

Notes:

- (a) Includes the following indicator compounds; acetone 2-butanone, 4-methyl-2-pentanone
- (b) Includes the following indicator compounds; benzene, toluene, xylenes, ethylbenzene, styrene, pentachlorophenol, 2,4-dichlorophenol, 4-chloro-3-methylphenol
- (c) Includes the following indicator compounds; methylene chloride, chloroform, carbon tetrachloride, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethene
- (d) Includes the following indicator compounds; bis(2-ethylhexyl)phthalate, di-n-butyl phthalate di-n-octyl phthalate, diethyl phthalate, butylbenzyl phthalate
- (e) Includes all PAH indicator compounds
- (f) Includes the following indicator compounds; n-nitrosodiphenylamine, n-nitrosodi-n-propylamine
- (g) Includes the following indicator compounds; PCB-1242, PCB-1248
- (h) Includes the following indicator compounds; heptachlor epoxide, dieldrin, endrin, 4'-DDD.
- (i) Includes the following indicator compounds; cadmium, lead

Sources:

- (1) Versar, 1979a
- (2) Versar, 1979b
- (3) Clement Associates, Inc., 1985

- Airborne Transport - Site contaminants may be transported via erosion of contaminated soil particles or dust or via evaporation of volatile organics from contaminated soil to the ambient air. The detection of relatively low concentrations of indicator compounds in surface soils suggests airborne transport is a minor route of contaminant migration. A significant degree of soil disturbance is likely to increase the potential for contaminant transport via air.
- Contaminated Sediment Transport Via Surface Water Runoff - Surface water runoff could transport onsite contaminated soil to offsite locations. The relatively low concentrations of constituents detected in onsite surface soil samples suggest this is a minor route of contaminant migration.

The distance of surface water bodies from the site suggests transport of contaminants via surface water is not of concern. Toms River is located approximately 1.3 miles east of the site. No surface drainage to Toms River occurs within 0.75 miles from the site. Insufficient data on regional groundwater flow are available to determine if transport via groundwater to surface water is of concern.

6.4.3 Identification of Receptors

Human and environmental receptors that may be potentially exposed to hazardous constituents associated with the site have been identified. These include:

- Human receptors - Human receptors include people residing within a 1-mile radius of the site boundaries. Populations who reside at a greater distance from the site but who may use areas surrounding the site for recreational or work-related purposes are also considered potential receptors.
- Environmental receptors - Terrestrial wildlife and domestic animals that live within or traverse the study area who may come into direct contact with site-associated hazardous constituents.

The site is located within a mixed residential, commercial, and agricultural area. Land use in the vicinity of the site is primarily residential and agricultural, although some commercial development exists to the west and south. Dense wooded areas are present to the north and east.

Approximately 563 persons live within a 1/4-mile radius. The closest residential dwellings are located approximately 600 feet from the site.

Commercial facilities in the immediate site vicinity include the Toms River Heating and Air Conditioning Company and an automobile restoration firm. The L-Ed Construction Company, whose primary business is the sale of cement and cement products, occupies the site.

Biological sampling or environmental surveys were not conducted during the RI. However, onsite activities by the L-Ed Construction company suggests the site provides only marginal suitable habitat for wildlife. Noise, site activities, and the lack of vegetation on the site would disturb most wildlife. Terrestrial environmental receptors most likely impacted include small mammals, rodents, and avifauna. The site is unlikely to support larger wildlife or prey species.

A detailed characterization of the receptors most likely at risk via each potential exposure pathway is provided in the following subsection.

6.4.4 Exposure Pathways

There are three environmental media by which human and environmental receptors may come into contact with contaminants present at the site: groundwater, surface soil, and ambient air. Exposure to contaminated media may occur through different routes for each of the identified potential receptors.

The following is a media-by-media discussion of the major routes of exposure to hazardous constituents associated with the site. This section also identifies human populations and environmental receptors most likely at risk via each potential exposure pathway.

6.4.4.1 Groundwater

Exposure to contaminated groundwater represents the primary potential route of human exposure to hazardous compounds. At present there are no data that indicate receptors are exposed to site-associated hazardous constituents in groundwater.

Sampling and analysis of onsite groundwater and groundwater immediately downgradient of the site indicated the presence of HSL organic compounds. The major contaminants detected include

trichloroethene, tetrachloroethene, 1,1-dichloroethane, and 1,1,1-trichloroethane. Although constituents were detected in residential and municipal wells, the source of these compounds has not been established.

Receptors in the immediate vicinity of the site use municipal water as a water supply source. In 1974, a zone system, which regulated the use of groundwater in the immediate site vicinity, was implemented as a result of identified groundwater contamination (TRW, 1986). Two zones, shown in Figure 1-5 (Section 1.0) were established (TRW, 1986). These are:

Zone I - Includes locations where groundwater was found to be contaminated. Groundwater in this area cannot be used as a water supply source. No new wells are to be installed and all new and existing homes were required to connect the Toms River Water Company (TRWC) water supply system.

Zone II - Includes areas which are susceptible to groundwater contamination because of their location with respect to groundwater movement. All new wells installed in Zone II are required to be screened in the Kirkwood Formation.

A residential well survey was implemented during the RI to identify groundwater users in the vicinity of the site. The results indicate the following:

- No potable water supply wells in Zone I were identified. However, two irrigation wells (Well No. 1 and Well No. 4; Figure 4-8), were identified in this zone. Both of these wells are screened in the Cohansey Formation.
- Two potable wells, screened in the Kirkwood Formation, were identified downgradient of the site in Zone II. These wells include the Jewish Community Center Swimming Pool (Well No. 8; Figure 4-9) and one residential well (Well No. 3; Figure 4-8). Numerous private wells are also located along the southern boundary of Zone II at a distance of approximately 5,500 to 8,000 feet from the site.
- Residences and businesses located upgradient of the site in Zone II (north of Church Road and east of Old Freehold Road) use groundwater as a water supply source. The nearest well to the site (upgradient) is located 1,300 feet west-northwest along Lakewood Road (Villager Bar; well No. 7, Figure 4-8).

In addition, the Toms River Water Company (TRWC) supplies municipal water from eight production wells at the Parkway Well Field. The well field is located 4,500 feet and 5,500 feet southeast of the site. The total well field pumping capacity is 5.75 million gallons per day. The TRWC also maintains a Cohansey Production well at the intersection of Indian Head and Whitesville Road. The location of these wells are shown in Figure 4-8.

The major potential route of exposure to site contaminants is via ingestion if contaminants migrate to wells used as a water supply source. Domestic use of contaminated groundwater can also contribute to the total dose a potential receptor would receive. Dermal contact or inhalation exposure may occur through uses such as bathing or showering. Exposure scenarios will be evaluated for potential ingestion, dermal exposure during bathing, and inhalation during showering.

Exposure may also occur through nonpotable use of groundwater. Exposure pathways include occasional, intermittent inhalation, dermal contact or ingestion associated with uses such as irrigation, (including the irrigation of vegetables grown for human consumption), food preparation, etc.

It must be emphasized that there are presently no data that indicate receptors are exposed to compounds in groundwater that are associated with the Reich Farm Site. HSL organic and inorganic constituents were detected in municipal water supply wells and domestic wells located both upgradient and downgradient of the site. Presently, there are insufficient data on regional groundwater flow or localized pumping influences to determine if these constituents are site-related. However, to completely characterize potential health effects, the risk assessment will consider exposure to contaminants present in monitoring wells, municipal wells, and residential wells.

6.4.4.2 Subsurface Soils

Presently, there is no basis for assessing exposure or risk to onsite contaminated subsurface soils. Although these compounds are a source of environmental contamination, the potential for direct human exposure under present site conditions is highly unlikely. A significant degree of soil disturbance at some future time may increase the potential for human and environmental exposure.

6.4.4.3 Surface Soils

Sampling and analysis of onsite surface soils indicate the presence of relatively low concentrations HSL organic contaminants. The major potential routes of human exposure to contaminated surface soil are via dermal contact and accidental ingestion.

There are no quantitative data on the size of the population potentially exposed to onsite soils via direct contact. Access to the site is not restricted. Thus, any receptors entering the site boundaries are potentially at risk of exposure.

Receptors with the greatest potential risk include employees of the L-Ed Construction Company who may come into contact with surface soils on a daily basis. The most likely exposure pathway is via dermal contact. Consequently, potential exposures for this group of receptors will be evaluated in the quantitative estimations of health impacts.

An additional identified group of receptors include persons living near the site in nearby residential communities or employees of adjacent businesses who may traverse the site and come into direct contact with soil contaminants. It is unlikely that adults, other than employees of the onsite construction company, would come into contact with onsite soils to a significant degree.

The most likely receptors at risk are children who may occasionally play onsite. Potential routes of exposure include dermal contact and accidental ingestion. Exposures to onsite soils by children are expected to occur relatively infrequently and would be of a limited duration. The presence of an active construction company onsite suggests the potential for long-term, repeated contact is minimal. An older child is considered the most likely receptor to be exposed to onsite surface soil contaminants.

Terrestrial wildlife or domestic animals from residential homes may also be exposed to onsite contaminated surface soils. Terrestrial mammals such as small rodents, burrowing mammals, or birds are likely environmental receptors that may come into direct contact with contaminants present in surface soils. Modes of exposure include dermal contact or ingestion.

6.4.4.4 Air

Receptors may be exposed to site-associated contaminants from inhalation of ambient air. Contaminants may enter ambient air as vapors volatilized from contaminated surface soil or

adsorbed to soil particulates or dusts that are transported by wind erosion and vehicular traffic. Any receptors living in adjacent communities or persons who work on the site, or frequent areas near the site, could potentially be exposed to airborne contaminants.

Ambient air sampling was not conducted during the RI. To identify potential exposure concentrations, two contaminant transport models proposed by Versar (1986), and Cowherd et. al (1984) were employed. Estimates of ambient air concentrations generated by the models are used to estimate potential exposure levels for receptors at risk. The methodology and assumptions used in the models are provided in Appendix H. Two receptors at risk are identified: (1) a receptor who works on the site who may be exposed on a periodic basis for 8 hours per day, and (2) a residential receptor who lives in the vicinity of the site (600 feet downwind) who could potentially be exposed to contaminants on a daily basis for 24 hours per day.

6.4.4.5 Summary

The preceding discussion identified the major potential routes of exposure to site contaminants and receptors most likely at risk via each exposure pathway. To focus the evaluation, a summary is provided in Table 6-5.

6.4.5 Quantitative Estimates of Exposure

Sections 6.4.3 and 6.4.4 identified human and environmental receptors and exposure pathways of concern. The final step in conducting an exposure assessment requires a quantitative determination of the potential exposure levels (i.e., the duration and frequency of contact) for the major routes of human exposure to site-associated contaminants. This section also identifies environmental exposure concentrations for the indicator compounds selected to evaluate public health and environmental risks.

6.4.5.1 Groundwater (Monitoring Wells)

Sampling and analysis of groundwater downgradient of the site indicated the presence of HSL organic contaminants. Because of groundwater use restrictions, there are no receptors in the immediate vicinity of the site (Zone 1) who use groundwater as a source of potable water.

Presently, insufficient data are available to estimate the concentrations of contaminants at a potential receptor location if the contaminants would migrate to potable wells. In addition,

TABLE 6-5

**SUMMARY OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS AT RISK
REICH FARM SITE**

Environmental Media	Receptors at Risk	Exposure Pathway
Groundwater	Groundwater users in the vicinity of the site	Ingestion Inhalation during showering Dermal exposure during bathing. Occasional dermal, inhalation, or ingestion exposure associated with nonpotable use of groundwater
Onsite Surface Soil	Construction company employees Children from nearby residences Terrestrial wildlife	Dermal contact Dermal contact Inadvertent ingestion Dermal contact Inadvertent ingestion
Ambient Air	Residents of nearby homes Persons who work on or in the vicinity of the site or who frequent areas near the site on a daily or periodic basis Terrestrial wildlife	Inhalation of vapors Inhalation of particulates Inhalation of vapors Inhalation of particulates Inhalation of vapors Inhalation of particulates

insufficient data are available to evaluate the influence of localized pumping influences on hydraulic gradients and subsequent contaminant migration. Consequently, to evaluate the potential for adverse health impacts, the concentrations of indicator compounds detected in downgradient monitoring wells (monitoring wells MW3 through MW10) were used to estimate potential exposures. Contaminants detected in these wells include the following.

Constituent	Average Concentration ($\mu\text{g/l}$)	Maximum Concentration ($\mu\text{g/l}$)
1,1-dichloroethane	0.4	2
trans-1,2-dichloroethene	1.0	5
1,1,1-trichloroethene	18.2	78
tetrachloroethene	1.3	7
trichloroethene	2.1	9
toluene	0.4	3
bis(2-ethylhexyl)phthalate	2.4	10
di-n-octyl phthalate	0.5	4
n-nitrosodiphenylamine	0.8	6
lead	9.7	33

Exposure scenarios considered include long-term ingestion, inhalation during showering, dermal exposure during bathing, and exposure associated with nonpotable use such as irrigation or the preparation of food. Quantitative exposure scenarios are described below.

Ingestion of Contaminated Groundwater

To estimate future exposure to contaminated groundwater via ingestion, it is assumed an adult weighing 70 kg would ingest 2 liters of water per day over a 70 year lifetime. It is assumed that 100 percent of an organic constituent and 50 percent of the lead are absorbed in the gastrointestinal tract (USEPA, 1984f). To provide a range of potential exposure levels, both the average and maximum concentrations of indicator contaminants detected in monitoring well samples are considered.

Inhalation During Showering

Potential future inhalation of volatile organic contaminants associated with domestic use of groundwater would contribute to the exposure level that a receptor could receive. To estimate exposure levels associated with inhalation during showering, several assumptions were made. These include:

- 190 liters of water are used during showering (USEPA, 1985c)
- The estimated dimensions of a bathroom are 12 m³ (USEPA, 1985c)
- 50 percent of the contaminants volatilize to the air (Andelman, 1985)
- 0.33 hr/day are spent in the shower (USEPA, 1985c)
- 1.2 m³/hr of air are inhaled

The exposure scenario will consider a 70 kg adult who may be exposed via inhalation over a 70 year lifetime. Exposures to the average and maximum concentrations will be considered to provide a range of exposure estimates. Only volatile organic indicator compounds (compounds with a vapor pressure greater than 10⁻³ mm Hg) are considered in the assessment. Phthalate esters, PAHs, and inorganics do not volatilize to the air to any significant degree.

Dermal Exposure During Bathing

Dermal exposure to contaminated groundwater may occur through bathing. The most likely exposure scenario assumes a 70 kg man bathes 20 minutes per day (0.33 hr/day) over a 70-year lifetime (Versar, 1986). This scenario assumes the whole body surface area of an adult (18,150 cm²) in direct contact with contaminated water (Versar, 1986). The water flux through the skin is estimated to 0.5 mg/cm²-hr (McLaughlin, 1985). To provide a range of exposure estimates, the average and maximum concentration of indicator compounds (with the exception of inorganic constituents, which are not known to be dermally absorbed) are considered.

Nonpotable Use

No quantitative data are available to estimate exposures associated with dermal, inhalation, or ingestion of contaminated groundwater during activities such as irrigation, car washing, lawn watering, or food preparation. The degree of exposure would depend on human activity patterns and factors such as the frequency and duration of exposure.

6.4.5.2 Groundwater (Municipal Wells)

HSL organic and inorganic constituents were detected in groundwater samples obtained from the Toms River Water Company production wells. Indicator compounds detected in these wells include 2-butanone, 4-methyl-2-pentanone, tetrachloroethene, trichloroethene, toluene, benzene, di-n-butyl phthalate, n-nitrosodiphenylamine, and lead. Most of the detections are below the CLP detection limits. Table 6-1 summarizes the concentration ranges and the average concentrations for each of the indicator compounds.

Insufficient data are available to identify the source of these compounds. Regional groundwater flow data and/or information on the potential for alterations in hydraulic gradients from pumping influences have not been determined. Presently, it is not known whether the Reich Farm Site is the source of these contaminants.

However to characterize potential health risks, exposure to these contaminants was considered. To estimate a "worst-case" potential exposure, it is assumed a receptor could be exposed to the average and maximum concentrations detected in these wells. Dilution and contaminant attenuation in the water supply distribution system were not considered. These factors are likely to significantly reduce exposure concentrations.

Exposure scenarios considered include long-term ingestion, inhalation during showering, and dermal exposure during bathing. Assumptions used to characterize exposure are the same as those described in Section 6.4.5.1.

6.4.5.3 Groundwater (Residential Wells)

HSL organic and inorganic constituents were also detected in residential wells located both upgradient and downgradient of the site. Constituents detected in the residential well samples are summarized below:

- Well No. 3 (Bouch Residence) - 2-Butanone, 13 µg/l; tetrachloroethene, 1 µg/l; n-nitrosodiphenylamine; 120 µg/l; isophorone, 58 µg/l; 2,4-dichlorophenol, 54 µg/l; 4-chloro-3-methylphenol, 46 µg/l; 2-chloronaphthalene, 58 µg/l; pentachlorophenol, 54 µg/l; benzo(k)fluoranthene, 40 µg/l; heptachlor epoxide, 22 µg/l; dieldrin, 14 µg/l; endrin, 0.28 µg/l; 4,4'-DDD, 0.42 µg/l. These constituents were not detected in the duplicate sample.

- Well No. 6 (Westra Residence) - 2-butanone; 5 µg/l
- Well No. 7 (Villager Bar) - Chloroform, 3 µg/l; 1,1,1-trichloroethane, 5 µg/l; carbon tetrachloride, 7 µg/l; bromoform, 8 µg/l; tetrachloroethene, 5 µg/l.
- Well No. 8 (Jewish Community Center Swimming Pool) - cadmium, 273 µg/l.

Insufficient data are available to determine if these compounds are site-related. Additional sampling and analysis is recommended. However, to characterize potential health risks, exposure to these contaminants were considered.

Exposure scenarios considered include ingestion, inhalation during showering, and dermal exposure during bathing. Assumptions used to characterize these scenarios are the same as those described in Section 6.4.5.2. For wells used as a water supply source for other purposes (i.e., Jewish Community Center Swimming Pool and the Village Bar), only long-term ingestion was considered to estimate the potential for health impacts under "worst-case" conditions.

6.4.5.4 Surface Soil

Indicator compounds detected in onsite surface soil include several volatile organics, phthalate esters, and PAHs. Inorganic constituents were not detected in onsite soil at elevated levels. Environmental exposure concentrations (average and maximum concentrations) are provided in Table 6-1.

Scenarios associated with exposure to contaminated surface soil include dermal contact and accidental ingestion by children and dermal contact by adults. Assumptions used to derive the exposure scenarios are described below.

Dermal Contact with Onsite Soils - Child

The most probable exposure scenario assumes a child would come into direct contact with contaminated surface soil twice a week during 12 weeks of the summer (24 times per year) for 10 years. It is expected that an older child (8 to 18 years of age) is the most likely receptor. The average weight of the child is assumed to be 45 kg (Anderson, et al., 1985).

The estimated amount of soil contacting the skin is 0.5 mg/cm² per day (Versar, 1986). Forty percent (hand and arms) of the total body surface area of a child (12,000 cm²) is likely to be in direct contact with contaminated soil (Anderson, et al., 1984; Schaum, 1984).

The estimated percentages of contaminants absorbed through the skin are; 100 percent of the volatile organic indicator compounds and 3 percent of the phthalate esters and PAHs (estimated fraction based on similar octanol water partition coefficients to 2,3,7,8-tetrachlorodibenzo-p-dioxin) (McLaughlin, 1984; Schaum, 1984). Volatile organics would readily volatilize from the skin following direct contact, consequently exposure estimates are likely to be over-estimated. Inorganics are not dermally absorbed to any degree and were not detected at elevated levels. Consequently, these constituents are not considered in the quantitative estimation of health impacts.

Dermal Contact with Offsite Soils - Adult

This potential exposure pathway considers adult onsite employees who may be exposed to surface soil contaminants on a daily basis. To characterize this exposure scenario, the following assumptions were made:

- A realistic worst-case exposure scenario assumes a 70 kg man could be exposed to contaminated soil 260 days per year for 20 years.
- The amount of soil contacted daily is 0.5 mg per cm², which provides a worst-case estimate of potential exposure levels (Versar, 1986).

It is assumed a receptor could come into contact with the average and maximum concentrations of indicator compounds to provide a range of exposure estimates. Absorption rates are the same as those described for dermal exposures to children.

Accidental Ingestion of Onsite and Offsite Surface Soil - Child

This scenario assumes exposure of a 45 kg child (ages 8-18) to onsite contaminated soils. The exposure duration is assumed to be approximately 24 days per year for 10 years. The estimated quantity of soil ingested is 0.1 gram per day (Schaum, 1984).

It is assumed that 100 percent of the organic indicator compounds may be absorbed through the gastrointestinal tract. Inorganics which were not detected in onsite soils at elevated levels were not considered.

6.4.5.5 Air (Inhalation of Vapors and Particulates)

Exposure to site-associated contaminations in ambient air may occur via the inhalation of volatilized surface soil contaminants or inhalation of airborne contaminated soil or dusts. Estimated exposure concentrations are presented in Appendix H.

To characterize potential risks to a residential receptor and a receptor who works onsite, two potential exposure scenarios were developed. These include:

- A residential receptor (70 kg man) located 600 feet downwind of the site who inhales 20 m³ of air per day over a lifetime.
- A receptor (70 kg man) who works onsite who inhales 20 m³ of air per day, 8 hours per day (workday exposure), for 20 years.

In both scenarios, it is assumed that 100 percent of the organic indicator compounds (both vapors and particulates) are absorbed upon entering the lungs. Inorganic constituents, which were not detected in surface soils at elevated levels, were not considered.

6.5 Risk Characterization

The hazard and exposure assessments presented in Sections 6.2 and 6.4 provided a characterization of potential exposures and hazards posed by the contaminants detected at the site. In the following section, the results of the hazard and exposure assessments are combined to determine the actual or potential public health and environmental risks resulting from exposure to hazardous constituents.

6.5.1 Human Health Impacts

Both quantitative and qualitative assessments of potential human health risks are presented in this section. Qualitative and quantitative risk estimates give an indication of the magnitude of the potential for adverse health impacts resulting from exposure to toxic substances.

A quantitative risk assessment can be performed for carcinogens by converting estimated exposure levels to incremental lifetime cancer risk. For noncarcinogens, the ratio of estimated dose to an acceptable exposure level provides a quantitative indication of the potential for noncarcinogenic effects. A discussion of potential risks will also be performed by a comparison of observed environmental concentrations to relevant regulatory standards and guidelines.

Estimates of potential health impacts presented in this section are based on the exposure scenarios identified in Section 6.4. Route-specific dose estimates are calculated for each contaminant of concern. A dose is defined as the amount of a compound in milligrams (mg) absorbed by a receptor on a daily basis per kilogram of body weight. A dose can be estimated as follows:

$$\text{Dose (mg/kg-day)} = \frac{\text{Concentration in an Environmental Medium} \times \text{Contact Rate} \times \text{Exposure Duration} \times \text{Absorbed Fraction}}{\text{Body Weight}}$$

The dose calculated for noncarcinogens is the daily dose. The dose calculated for a known or suspected carcinogen is the daily dose averaged over a lifetime. Sample dose calculations for the exposure pathways of concern are provided in Appendix I.

To evaluate the potential for noncarcinogenic effects, the estimated daily dose (mg/kg/day) is compared directly to an Acceptable Daily Intake (ADI) (mg/kg/day). The ratio of the estimated exposure level to an acceptable exposure level provides a numerical indication of potential for adverse effects. ADIs for the indicator compounds are presented in Table 6-3. ADIs are available for oral and inhalation routes of exposure for noncarcinogens.

For known or suspected carcinogens, the estimated dose can be converted to incremental lifetime cancer risk. A carcinogenic risk estimate represents the probability or range of probabilities that a carcinogenic effect will occur. A carcinogenic risk estimate of 1×10^{-6} indicates that one person in one million people will develop cancer following exposure.

Carcinogenic risk can be calculated using the following equation:

$$\text{Risk} = (q)(\text{dose})$$

where:

q = Carcinogenic Potency Factor (CPF) (mg/kg-day)⁻¹

dose = Daily dose of compound averaged over an individual's lifetime and body weight

Estimation of lifetime cancer risk is limited to those compounds for which an evaluation has been conducted by the EPA Carcinogenic Assessment Group (CAG). CPFs, developed by the EPA CAG, are presented in Table 6-3.

Additive, synergistic, or antagonistic effects may also result from exposure to multiple indicator compounds present in environmental media. Synergistic or antagonistic interactions are possible although insufficient data are available to evaluate the influence of these interactions on quantitative estimates of health effects. However, additive effects can be quantified.

To assess the total potential for noncarcinogenic effects posed by multiple exposures, a hazard index can be calculated (USEPA, 1985c). This can be expressed as follows:

$$\text{Hazard Index} = E_1/AL_1 + E_2/AL_2 + \dots + E_i/AL_i$$

where:

E_i = Exposure level (or intake) for the i th toxicant

AL_i = Acceptable level (or intake) for the i th toxicant

When a hazard index is greater than one, exposure to an individual compound, or exposure to multiple subthreshold concentrations are of concern i.e., the potential exists for adverse noncarcinogenic effects. When a hazard index is less than or equal to 1, no adverse noncarcinogenic effects are expected. The hazard index is not a mathematical prediction of the incidence or severity of effects, it is simply a numerical indicator of the transition from acceptable to unacceptable exposure levels.

To assess the total risk posed by the presence of more than one known or suspected carcinogen for each exposure pathway, risk estimates are added. Total carcinogenic risk is estimated as follows (ICF Inc., 1985):

$$\text{Total Carcinogenic Risk} = [\text{Carcinogenic Risk for Chemical}_1 + \dots + \text{Carcinogenic Risk for Chemical}_n]$$

It must be emphasized that the estimation of the potential for noncarcinogenic effects and carcinogenic risk is dependent upon numerous assumptions. Many uncertainties are inherent in the process. Uncertainties include those associated with the toxicological data base (e.g., extrapolation of data from animal studies to effects in humans, high-to-low dose extrapolation, etc.) and the degree to which human exposure may be estimated or predicted. Despite these uncertainties, the quantitative risk estimates presented for the Reich Farm Site represent a realistic, upper-bound estimate of risks to receptors potentially exposed to hazardous constituents.

Quantitative risk estimates for the exposure pathways of concern are discussed below.

6.5.1.1 Groundwater

Monitoring Wells

Exposure to contaminated groundwater is the primary human exposure pathway to hazardous constituents. However, groundwater use in the immediate vicinity of the site is restricted.

Presently, insufficient data are available on the extent of groundwater contamination, the direction of regional groundwater flow, or the influence of pumping on alterations of hydraulic gradients and subsequent contaminant migration. Consequently, to evaluate potential health impacts, exposure to the concentrations detected in downgradient monitoring well samples was considered to evaluate worst-case exposures.

Tables 6-6 through 6-11 list the estimated health risks associated with ingestion, inhalation, and dermal exposure to the average and maximum concentrations of indicator compounds detected in monitoring well samples (MW-3 through MW-10). The hazard indices (noncarcinogenic effects) and the total estimated lifetime cancer risks are summarized below.

Table 6-6
Estimated Health Effects
Ingestion of Groundwater - Monitoring Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (Wg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
1,1-dichloroethane	0.4	1	1.14E-05	1.1E-01		1.04E-04	
trans-1,2-dichloroethene	1	1	2.86E-05				
1,1,1-trichloroethane	18.2	1	5.20E-04	5.4E-01		9.63E-04	
toluene	0.4	1	1.14E-05	2.9E-01		3.94E-05	
bis(2-ethylhexyl) phthalate	2.4	1	6.86E-05	6E-01		1.14E-04	
di-n-octyl phthalate	0.5	1	1.43E-05				
lead	9.7	0.5	1.39E-04	1.4E-03		9.90E-02	
Carcinogenic Effects							
trichloroethene	2.1	1	6.00E-05		1.2E-02		7.20E-07
tetrachloroethene	1.3	1	3.71E-05		6E-02		2.23E-06
n-nitrosodiphenylamine	0.8	1	2.29E-05		4.92E-03		1.12E-07
Total:						1.002E-01	3.061E-06

Notes : ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-7
Estimated Health Effects
Ingestion of Groundwater - Monitoring Wells
Maximum Concentration
Reich Farm site

Compound	Maximum Conc. (ug/L)	Absorbed Fraction	Estimated Lifetime Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
1,1-dichloroethane	2	1	5.71E-05	1.1E-01		5.19E-04	
trans-1,2-dichloroethene	5	1	1.43E-04				
1,1,1-trichloroethane	78	1	2.23E-03	5.4E-01		4.13E-03	
toluene	3	1	8.57E-05	2.9E-01		2.96E-04	
bis(2-ethylhexyl) phthalate	10	1	2.86E-04	6E-01		4.76E-04	
di-n-octyl phthalate	4	1	1.14E-04				
lead	33	0.5	4.71E-04	1.4E-03		3.37E-01	
Carcinogenic Effects							
trichloroethene	9	1	2.57E-04		1.2E-02		3.09E-06
tetrachloroethene	7	1	2.00E-04		6E-02		1.20E-05
n-nitrosodiphenylamine	6	1	1.71E-04		4.92E-03		8.43E-07
Total						3.422E-01	1.593E-05

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-8
Estimated Health Effects
Inhalation During Showering - Monitoring Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
1,1-dichloroethane	0.4	1.79E-05	1.4E-01		1.28E-04	
trans-1,2-dichloroethene	1	4.48E-05				
1,1,1-trichloroethane	18.2	8.15E-04	6.3E+00		1.29E-04	
toluene	0.4	1.79E-05	1.5E+00		1.19E-05	
Carcinogenic Effects						
trichloroethene	2.1	9.40E-05		1.2E-02		1.13E-06
tetrachloroethene	1.3	5.82E-05		6E-02		3.49E-06
Total					2.69E-04	4.62E-06

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-9
Estimated Health Effects
Inhalation During Showering - Monitoring Wells
Maximum Concentration
Reich Farm site

Compound	Maximum Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
1,1-dichloroethane	2	8.96E-05	1.4E-01		6.40E-04	
trans-1,2-dichloroethene	5	2.24E-04				
1,1,1-trichloroethane	78	3.49E-03	6.3E+00		5.54E-04	
toluene	3	1.34E-04	1.5E+00		8.96E-05	
Carcinogenic Effects						
trichloroethene	9	4.03E-04		1.2E-02		4.84E-06
tetrachloroethene	7	3.13E-04		6E-02		1.88E-05
Total:					1.28E-03	2.36E-05

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-10
Estimated Health Effects
Dermal Exposure During Bathing - Monitoring Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
1,1-dichloroethane	0.4	1.73E-08	1.1E-01		1.57E-07	
trans-1,2-dichloroethene	1	4.32E-08				
1,1,1-trichloroethene	18.2	7.87E-07	5.4E-01		1.46E-06	
toluene	0.4	1.73E-08	2.9E-01		5.96E-08	
bis(2-ethylhexyl) phthalate	2.4	1.04E-07	6E-01		1.73E-07	
di-n-octyl phthalate	0.5	2.16E-08				
Carcinogenic Effects						
trichloroethene	2.1	9.08E-08		1.2E-02		1.09E-09
tetrachloroethene	1.3	5.62E-08		6E-02		3.37E-09
n-nitrosodiphenylamine	0.8	3.46E-08		4.92E-03		1.70E-10
Total:					1.85E-06	4.63E-09

Notes: ADI - Acceptable Daily intake
CPF - Carcinogenic Potency Factor

Table 6-11
Estimated Health Effects
Dermal Exposure During Bathing - Monitoring Wells
Maximum Concentration
Reich Farm Site

Compound	Maximum Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
1,1-dichloroethane	2	8.64E-08	1.1E-01		7.86E-07	
trans-1,2-dichloroethene	5	2.16E-07				
1,1,1-trichloroethene	78	3.37E-06	5.4E-01		6.24E-06	
toluene	3	1.30E-07	2.9E-01		4.47E-07	
bis(2-ethylhexyl) phthalate	10	4.32E-07	6E-01		7.20E-07	
di-n-octyl phthalate	4	1.73E-07				
Carcinogenic Effects						
trichloroethene	9	3.89E-07		1.2E-02		4.67E-09
tetrachloroethene	7	3.03E-07		6E-02		1.82E-08
n-nitrosodiphenylamine	6	2.59E-07		4.92E-03		1.28E-09
Total:					8.20E-06	2.41E-08

Notes: ADI - Acceptable Daily intake
CPF - Carcinogenic Potency Factor

	Hazard Index (Noncarcinogenic Effects)		Estimated Lifetime Cancer Risk	
	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration
Ingestion of Groundwater	1.0×10^{-2}	3.4×10^{-1}	3.06×10^{-6}	1.59×10^{-5}
Inhalation during showering	2.69×10^{-4}	1.28×10^{-3}	4.62×10^{-6}	2.36×10^{-5}
Dermal exposure during bathing	1.85×10^{-6}	8.2×10^{-6}	4.63×10^{-9}	2.41×10^{-8}

The hazard index is less than 1 for all potential groundwater exposure pathways. The results indicate that long-term exposure to multiple noncarcinogenic contaminants of concern is unlikely to be associated with adverse health impacts. The carcinogenic risk estimates suggest a potential carcinogenic risk to receptors who may use contaminated groundwater at the observed concentrations.

A comparison of the concentrations of contaminants detected in groundwater to relevant regulatory standards and guidelines also provides a means to evaluate the potential for adverse health impacts. Relevant standards and guidelines include EPA Health Advisories, MCLs, RMCLs, and AWQC for the protection of human health from contaminants in drinking water. These parameters are presented in Table 6-3.

A measure of acute and subchronic toxic effects associated with ingestion can be estimated by comparing the observed concentrations with EPA 1-day and 10-day Health Advisories. None of the contaminants detected exceed these criteria. Consequently, adverse effects from short-term consumption are not expected.

The potential for effects (noncarcinogenic) associated with long-term ingestion at the observed concentrations can be made by a comparison to longer-term or lifetime Health Advisories and AWQC. None of the contaminants detected exceed these criteria. Based on this comparison, long-term exposure at the observed concentrations is unlikely to be associated with adverse health impacts. However, the concentration of trichloroethane ($7\text{-}8 \mu\text{g/l}$) exceeds the proposed MCL of $5 \mu\text{g/l}$. This proposed criteria considers not only health factors but also the technical feasibility of removing a compound from a water supply system.

Municipal Wells

Potential routes of exposure to contaminants identified in municipal well water samples include ingestion, inhalation during showering, and dermal exposure during bathing. To provide a worst-case estimate of potential exposures, it is assumed that a receptor is exposed to the concentrations detected in the samples. Contaminant attenuation or dilution in the water supply distribution system was not considered.

Tables 6-12 through 6-17 list the quantitative estimates of potential health impacts resulting from exposure to the average and maximum concentrations of indicator compounds detected. Hazard indices and the total estimated carcinogenic risk are summarized below.

	Hazard Index (Noncarcinogenic Effects)		Estimated Lifetime Cancer Risk	
	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration
Ingestion	7.22×10^{-2}	6.01×10^{-1}	5.48×10^{-7}	4.46×10^{-6}
Inhalation during showering	6.41×10^{-4}	3.75×10^{-3}	6.83×10^{-7}	5.2×10^{-6}
Dermal exposure during bathing	2.66×10^{-6}	1.43×10^{-5}	8.3×10^{-10}	6.74×10^{-9}

Hazard indices calculated for exposure to contaminants detected in municipal water supply wells are less than 1. This indicates the potential for adverse effects from long-term exposure to noncarcinogenic indicator contaminants or multiple subthreshold concentrations of indicator contaminants are unlikely to be associated with adverse health implications. The estimated lifetime carcinogenic risks are in the range of 10^{-6} to 10^{-9} which provide a 'worst-case' estimate of potential health impacts.

A comparison of the observed concentrations of organic contaminants detected in the municipal well samples to relevant regulatory standards and criteria presented in Table 8-3 indicates that none of the constituents were detected at levels associated with acute or chronic adverse health impacts. The concentration of lead detected in the TRWC Production Well No. 20 ($58 \mu\text{g/l}$) and the TRWC monitoring well located on Dugan Lane ($56 \mu\text{g/l}$) exceed the National Interim Primary Drinking

Table 6-12
Estimated Health Effects
Ingestion of Groundwater - Municipal Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
2-butanone	2.7	1	7.71E-05	4.6E-02		1.68E-03	
4-methyl-2-pentanone	0.2	1	5.71E-06	1.04E-01		5.49E-05	
toluene	0.1	1	2.86E-06	2.9E-01		9.85E-06	
di-n-butyl phthalate	0.6	1	1.71E-05	1.26E+00		1.36E-05	
lead	6.9	0.5	9.86E-05	1.4E-03		7.04E-02	
Carcinogenic Effects							
benzene	0.1	1	2.86E-06		2.9E-02		8.29E-08
trichloroethene	0.53	1	1.51E-05		1.2E-02		1.82E-07
tetrachloroethene	0.1	1	2.86E-06		6E-02		1.71E-07
n-nitrosodiphenylamine	0.8	1	2.29E-05		4.92E-03		1.12E-07
Total:						7.22E-02	5.48E-07

Notes : ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-13
Estimated Health Effects
Ingestion of Groundwater - Municipal Wells
Maximum Concentration
Reich Farm site

Compound	Maximum Conc. (ug/L)	Absorbed Fraction	Estimated Lifetime Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
2-butanone	14	1	4.00E-04	4.6E-02		8.70E-03	
4-methyl-2-pentanone	2	1	5.71E-05	1.04E-01		5.49E-04	
toluene	1	1	2.86E-05	2.9E-01		9.85E-05	
di-n-butyl phthalate	6	1	1.71E-04	1.26E+00		1.36E-04	
lead	58	0.5	8.29E-04	1.4E-03		5.92E-01	
Carcinogenic Effects							
benzene	1	1	2.86E-05		2.9E-02		8.29E-07
trichloroethene	2.3	1	6.57E-05		1.2E-02		7.89E-07
tetrachloroethene	1	1	2.86E-05		6E-02		1.71E-06
n-nitrosodiphenylamine	8	1	2.29E-04		4.92E-03		1.12E-06
Total:						6.01E-01	4.46E-06

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-14
Estimated Health Effects
Inhalation During Showering - Municipal Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	2.7	1.21E-04	2.19E-01		5.52E-04	
4-methyl-2-pentanone	0.2	8.96E-06	1.04E-01		8.61E-05	
toluene	0.1	4.48E-06	1.5E+00		2.99E-06	
Carcinogenic Effects						
benzene	0.1	4.48E-06		2.9E-02		1.30E-07
trichloroethene	0.53	2.37E-05		1.2E-02		2.85E-07
tetrachloroethene	0.1	4.48E-06		6E-02		2.69E-07
Total:					6.41E-04	6.83E-07

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-15
Estimated Health Effects
Inhalation During Showering - Municipal Wells
Maximum Concentration
Reich Farm site

Compound	Maximum Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	14	6.27E-04	2.19E-01		2.86E-03	
4-methyl-2-pentanone	2	8.96E-05	1.04E-01		8.61E-04	
toluene	1	4.48E-05	1.5E+00		2.99E-05	
Carcinogenic Effects						
benzene	1	4.48E-05		2.9E-02		1.30E-06
trichloroethene	2.3	1.03E-04		1.2E-02		1.24E-06
tetrachloroethene	1	4.48E-05		6E-02		2.69E-06
Total:					3.75E-03	5.22E-06

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-16
Estimated Health Effects
Dermal Exposure During Bathing - Municipal Wells
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	2.7	1.17E-07	4.6E-02		2.54E-06	
4-methyl-2-pentanone	0.2	8.64E-09	1.04E-01		8.31E-08	
toluene	0.1	4.32E-09	2.9E-01		1.49E-08	
di-n-butyl phthalate	0.6	2.59E-08	1.26E+00		2.06E-08	
Carcinogenic Effects						
benzene	0.1	4.32E-09		2.9E-02		1.25E-10
trichloroethene	0.53	2.29E-08		1.2E-02		2.75E-10
tetrachloroethene	0.1	4.32E-09		6E-02		2.59E-10
n-nitrosodiphenylamine	0.8	3.46E-08		4.92E-03		1.70E-10
Total:					2.66E-06	8.30E-10

Notes: ADI - Acceptable Daily intake
CPF - Carcinogenic Potency Factor

Table 6-17
Estimated Health Effects
Dermal Exposure During Bathing - Municipal Wells
Maximum Concentration
Reich Farm Site

Compound	Maximum Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	14	6.05E-07	4.6E-02		1.32E-05	
4-methyl-2-pentanone	2	8.64E-08	1.04E-01		8.31E-07	
toluene	1	4.32E-08	2.9E-01		1.49E-07	
di-n-butyl phthalate	6	2.59E-07	1.26E+00		2.06E-07	
Carcinogenic Effects						
benzene	1	4.32E-08		2.9E-02		1.25E-09
trichloroethene	2.3	9.94E-08		1.2E-02		1.19E-09
tetrachloroethene	1	4.32E-08		6E-02		2.59E-09
n-nitrosodiphenylamine	8	3.46E-07		4.92E-03		1.70E-09
Total:					1.43E-05	6.74E-09

Notes: ADI - Acceptable Daily intake
CPF - Carcinogenic Potency Factor

Water Standard MCL and the recommended MCL of 50 µg/l and 20 µg/l, respectively, indicating a potential for adverse effects associated with long-term ingestion. However, it must be emphasized that insufficient data are available to identify the source of the contaminants detected in municipal wells. Sampling and analysis of environmental media at the Reich Farm Site suggests the site is not a source of inorganic contamination. The data have also not been validated by quality assurance personnel as to the performance of the EPA Contract Laboratory.

Residential Wells

Potential routes of exposure to constituents detected in residential well samples include ingestion, inhalation during showering, and dermal exposure during bathing. For Well No. 8 (Jewish Community Center Swimming Pool) and Well No. 7 (Villager Bar), only long-term ingestion was considered.

Tables 6-18 through 6-25 list the quantitative estimates of potential health impacts resulting from exposure to the concentrations of indicator compounds detected in the residential well samples. The results are summarized below.

	Hazard Index (Noncarcinogenic Effects)	Estimated Lifetime Cancer Risk
Bouch Well		
• Ingestion	8.53×10^{-2}	1.22×10^{-2}
• Inhalation during showering	1.89×10^{-2}	2.69×10^{-6}
• Dermal exposure during bathing	1.29×10^{-4}	1.84×10^{-6}
Westra Well		
• Ingestion	3.10×10^{-3}	--
• Inhalation	1.02×10^{-3}	--
• Dermal exposure during bathing	4.7×10^{-6}	--
Villager Bar		
• Ingestion	2.65×10^{-4}	4.06×10^{-5}
Jewish Community Center Pool		
• Ingestion	1.61	--

Hazard indices are less than 1 for all potential exposure pathways other than long-term ingestion from the Jewish Community Center Swimming Pool Well. The hazard index of 1.61 is attributed to the high concentration (273 µg/l) of cadmium detected in this sample. The results indicate a

Table 6-18
Estimated Health Effects
Ingestion of Groundwater - Residential Well
Bouch Well (Sample No RF-RW-003)
Reich Farm Site

Compound	Conc (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
2-butanone	13	1	3.71E-04	4.6E-02		8.07E-03	
2,4-dichlorophenol	54	1	1.54E-03	1E-01		1.54E-02	
4-chloro-3-methylphenol	46	1	1.31E-03				
pentachlorophenol	54	1	1.54E-03	3E-02		5.14E-02	
2-chloronapthalene	58	1	1.66E-03				
isophorone	58	1	1.66E-03	1.6E-01		1.04E-02	
Carcinogenic Effects							
tetrachloroethene	1	1	2.86E-05		6E-02		1.71E-06
n-nitrosodi-n-propylamine	120	1	3.43E-03				
benzo(k)fluoranthene	40	1	1.14E-03				
heptachlor epoxide	22	1	6.29E-04				
dieldrin	14	1	4.00E-04		3.04E+01		1.22E-02
endrin	0.28	1	8.00E-06				
4,4'-DDD	0.42	1	1.20E-05				
Total:						8.53E-02	1.22E-02

Notes : ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor
Constituents detected in this well sample were not detected
in this duplicate sample.

Table 6-19
 Estimated Health Effects
 Ingestion of Groundwater - Residential Well
 Villager Bar Well (Sample No RF-RW-013)
 Reich Farm Site

Compound	Conc (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
1,1,1-trichloroethene	5	1	1.43E-04	5.4E-01		2.65E-04	
Carcinogenic Effects							
carbon tetrachloride	7	1	2.00E-04		1.3E-01		2.60E-05
chloroform	3	1	8.57E-05		7E-02		6.00E-06
tetrachloroethene	5	1	1.43E-04		6E-02		8.57E-06
Total:						2.65E-04	4.06E-05

Notes : ADI - Acceptable Daily Intake
 CPF - Carcinogenic Potency Factor

Table 6-20
 Estimated Health Effects
 Ingestion of Groundwater - Residential Well
 Westra Well (Sample No RF-RW-006)
 Reich Farm Site

Compound	Conc. (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
2-butanone	5	1	1.43E-04	4.6E-02		3.11E-03	
Total:						3.11E-03	

Notes : ADI - Acceptable Daily Intake
 CPF - Carcinogenic Potency Factor

Table 6-21
 Estimated Health Effects
 Ingestion of Groundwater - Residential Well
 Jewish Community Center (Sample No RF-MW-012)
 Reich Farm Site

Compound	Conc. (ug/L)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
cadmium	273	0.06	4.68E-04	2.9E-04		1.61E+00	
Total:						1.61E+00	

Notes : ADI - Acceptable Daily Intake
 CPF - Carcinogenic Potency Factor

Table 6-22
 Estimated Health Effects
 Inhalation During Showering - Residential Well
 Bouch Well (Sample No RF-RW-003)
 Reich Farm Site

Compound	Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	13	5.82E-04	2.19E-01		2.66E-03	
isophorone	58	2.60E-03	1.6E-01		1.62E-02	
Carcinogenic Effects						
tetrachloroethene	1	4.48E-05		6E-02		2.69E-06
Total:					1.89E-02	2.69E-06

Notes: ADI - Acceptable Daily Intake
 CPF - Carcinogenic Potency Factor
 Constituents detected in this well sample were not detected
 in the duplicate sample.

Table 6-23
 Estimated Health Effects
 Inhalation During Showering - Residential Well
 Westra Well (Sample No RF-RW-006)
 Reich Farm Site

Compound	Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	5	2.24E-04	2.19E-01		1.02E-03	
Total:					1.02E-03	

Notes: ADI - Acceptable Daily Intake
 CPF - Carcinogenic Potency Factor

Table 6-24
Estimated Health Effects
Dermal Exposure During Bathing - Residential Well
Bouch Well (Sample No RF-RW-003)
Reich Farm Site

Compound	Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	13	5.62E-07	4.6E-02		1.22E-05	
2,4-dichlorophenol	54	2.33E-06	1E-01		2.33E-05	
4-chloro-3-methylphenol	46	1.99E-06				
pentachlorophenol	54	2.33E-06	3E-02		7.78E-05	
2-chloronaphthalene	58	2.51E-06				
isophorone	58	2.51E-06	1.6E-01		1.57E-05	
Carcinogenic Effects						
tetrachloroethene	1	4.32E-08		6E-02		2.59E-09
n-nitrosodi-n-propylamine	120	5.19E-06				
benzo(k)fluoranthene	40	1.73E-06				
heptachlor epoxide	22	9.51E-07				
dieldrin	14	6.05E-07		3.04E+01		1.84E-05
endrin	0.28	1.21E-08				
4,4'-DDD	0.42	1.82E-08				
Total:					1.29E-04	1.84E-05

Notes: ADI - Acceptable Daily intake
CPF - Carcinogenic Potency Factor
Constituents detected in this sample were not detected
in the duplicate sample.

Table 6-25
 Estimated Health Effects
 Dermal Exposure During Bathing - Residential Well
 Westra Well (Sample No RF-RW-006)
 Reich Farm Site

Compound	Conc. (ug/L)	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects						
2-butanone	5	2.16E-07	4.6E-02		4.70E-06	
Total:					4.70E-06	

Notes: ADI - Acceptable Daily intake
 CPF - Carcinogenic Potency Factor

potential for health effects from long-term ingestion if the well water is used as a potable water supply source. However, the site has not been implicated as a source of cadmium. In addition, the data have not been validated by quality assurance personnel.

Estimated carcinogenic risks associated with exposure are in the range of 10^{-2} to 10^{-6} . Constituents detected in the Bouch Well were not detected in the duplicate sample. The Villager Bar is presently located upgradient of the site. The source of these compounds has not been established. Additional sampling and analysis is recommended.

A comparison of the observed concentrations detected in residential well samples to relevant standards and criteria also indicates a potential for acute or chronic health impacts (noncarcinogenic) from ingestion. The concentration of cadmium in the Jewish Community Center Swimming Pool exceeds the MCL of $10 \mu\text{g/l}$, the proposed RMCL of $5 \mu\text{g/l}$, and EPA Health Advisories for short-term (1- and 10-day) and long-term consumption. Based on this comparison, acute and chronic effects associated with ingestion at the observed concentration of cadmium are likely.

6.5.1.2 Surface Soil

Exposure scenarios considered for potential contact with contaminated surface soil include children who may occasionally be exposed to onsite soil via dermal contact and accidental ingestion and adult employees of the Le-Ed Construction Company who may come into contact with the contaminated soil on a daily basis.

Tables 6-26 through 6-31 list the quantitative estimates of potential health impacts resulting from exposures to the average and maximum concentrations of indicator compounds detected in onsite surface soils. The results are summarized below.

Table 6-26
Estimated Health Effects
Dermal Exposure to Onsite Surface Soils - Child
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	8	1	4.27E-07	3E+00		1.42E-07	
2-butanone	7.4	1	3.95E-07	4.6E-02		8.58E-06	
1,1,1-trichloroethane	1	1	5.33E-08	5.4E-01		9.88E-08	
trans-1,2-dichloroethene	0.2	1	1.07E-08				
toluene	25	1	1.33E-06	2.9E-01		4.60E-06	
ethylbenzene	18	1	9.60E-07	9.7E-02		9.90E-06	
xylenes	55	1	2.93E-06	1E-02		2.93E-04	
chlorobenzene	34	1	1.81E-06	2.7E-02		6.72E-05	
bis(2-ethylhexyl) phthalate	2448	0.03	3.92E-06	6E-01		6.53E-06	
di-n-octyl phthalate	114	0.03	1.82E-07				
di-n-butyl phthalate	53	0.03	8.48E-08	1.26E+00		6.73E-08	
butylbenzyl phthalate	154	0.03	2.46E-07				
fluoranthene	36	0.03	5.76E-08	6E-03		9.60E-06	
pyrene	22	0.03	3.52E-08				
Carcinogenic Effects							
tetrachloroethene	8	1	4.01E-09		6E-02		2.40E-10
Total:						4.00E-04	2.40E-10

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-27
Estimated Health Effects
Dermal Exposure to Onsite Surface Soils - Child
Maximum Concentration
Reich Farm Site

Compound	Maximum Conc. (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	17	1	9.07E-07	3E+00		3.02E-07	
2-butanone	11	1	5.87E-07	4.6E-02		1.28E-05	
1,1,1-trichloroethane	7	1	3.73E-07	5.4E-01		6.91E-07	
trans-1,2-dichloroethene	1	1	5.33E-08				
toluene	99	1	5.28E-06	2.9E-01		1.82E-05	
ethylbenzene	59	1	3.15E-06	9.7E-02		3.24E-05	
xylenes	180	1	9.60E-06	1E-02		9.60E-04	
chlorobenzene	100	1	5.33E-06	2.7E-02		1.98E-04	
bis(2-ethylhexyl) phthalate	5700	0.03	9.12E-06	6E-01		1.52E-05	
di-n-octyl phthalate	570	0.03	9.12E-07				
di-n-butyl phthalate	110	0.03	1.76E-07	1.26E+00		1.40E-07	
butylbenzyl phthalate	420	0.03	6.72E-07				
fluoranthene	180	0.03	2.88E-07	6E-03		4.80E-05	
pyrene	110	0.03	1.76E-07				
Carcinogenic Effects							
tetrachloroethene	22	1	1.10E-08		6E-02		6.61E-10
Total:						1.29E-03	6.61E-10

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-28
Estimated Health Effects
Dermal Exposure to Onsite Surface Soils - Adult
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	8	1	1.68E-07	3E+00		5.6E-08	
2-butanone	7.4	1	1.55E-07	4.6E-02		3.38E-06	
1,1,1-trichloroethene	1	1	2.1E-08	5.4E-01		3.89E-08	
trans-1,2-dichloroethene	0.2	1	4.2E-09				
toluene	8	1	1.68E-07	2.9E-01		5.79E-07	
ethylbenzene	18	1	3.78E-07	9.7E-02		3.90E-06	
xylene	55	1	1.16E-06	1E-02		1.16E-04	
chlorobenzene	34	1	7.14E-07	2.7E-02		2.64E-05	
bis(2-ethylhexyl) phthalate	2448	0.03	1.54E-06	6E-01		2.57E-06	
di-n-octyl phthalate	114	0.03	7.18E-08				
di-n-butyl phthalate	53	0.03	3.34E-08	1.26E+00		2.65E-08	
butyl benzyl phthalate	154	0.03	9.70E-08				
fluoranthene	36	0.03	2.27E-08	6E-03		3.78E-06	
pyrene	22	0.03	1.39E-08				
Carcinogenic Effects							
tetrachloroethene	8	1	3.42E-08		6E-02		2.05E-09
Total:						1.56E-04	2.05E-09

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-29
Estimated Health Effects
Dermal Exposure to Onsite Surface Soils - Adult
Maximum Concentration
Reich Farm Site

Compound	Maximum Conc. (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	17	1	3.57E-07	3E+00		1.19E-07	
2-butanone	11	1	2.31E-07	4.6E-02		5.02E-06	
1,1,1-trichloroethene	7	1	1.47E-07	5.4E-01		2.72E-07	
trans-1,2-dichloroethene	1	1	2.1E-08				
toluene	99	1	2.08E-06	2.9E-01		7.17E-06	
ethylbenzene	59	1	1.24E-06	9.7E-02		1.28E-05	
xylene	180	1	3.78E-06	1E-02		3.78E-04	
chlorobenzene	100	1	2.1E-06	2.7E-02		7.78E-05	
bis(2-ethylhexyl) phthalate	5700	0.03	3.59E-06	6E-01		5.99E-06	
di-n-octyl phthalate	570	0.03	3.59E-07				
di-n-butyl phthalate	110	0.03	6.93E-08	1.26E+00		5.5E-08	
butyl benzyl phthalate	420	0.03	2.65E-07				
fluoranthene	180	0.03	1.13E-07	6E-03		1.89E-05	
pyrene	110	0.03	6.93E-08				
Carcinogenic Effects							
tetrachloroethene	22	1	9.40E-08		6E-02		5.64E-09
Total:						5.06E-04	5.64E-09

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-30
Estimated Health Effects
Accidental Ingestion of Surface Soil - Child
Average Concentration
Reich Farm Site

Compound	Average Conc. (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	8	1	1.78E-08	3E+00		5.93E-09	
2-butanone	7.4	1	1.64E-08	4.6E-02		3.57E-07	
1,1,1-trichloroethane	1	1	2.22E-09	5.4E-01		4.12E-09	
trans 1,2-dichloroethane	0.2	1	4.44E-10				
toluene	25	1	5.56E-08	2.9E-01		1.92E-07	
ethylbenzene	18	1	4.00E-08	9.7E-02		4.12E-07	
xylene	55	1	1.22E-07	1E-02		1.22E-05	
chlorobenzene	34	1	7.56E-08	2.7E-02		2.80E-06	
bis(2-ethylhexyl)phthalate	2448	1	5.44E-06	6E-01		9.07E-06	
di-n-octyl phthalate	114	1	2.53E-07				
di-n-butyl phthalate	53	1	1.18E-07	1.26E+00		9.35E-08	
butylbenzyl phthalate	154	1	3.42E-07				
fluoranthene	36	1	8.00E-08	6E-03		1.33E-05	
pyrene	22	1	4.89E-08				
Carcinogenic Effects							
tetrachloroethene	8	1	1.67E-10		6E-02		1.00E-11
Total:						3.85E-05	1.00E-11

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-31
Estimated Health Effects
Accidental Ingestion of Surface Soil - Child
Maximum Concentration
Reich Farm Site

Compound	Maximum Conc (ug/kg)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	17	1	3.78E-08	3E+00		1.26E-08	
2-butanone	11	1	2.44E-08	4.6E-02		5.31E-07	
1,1,1-trichloroethane	7	1	1.56E-08	5.4E-01		2.88E-08	
trans 1,2-dichloroethane	1	1	2.22E-09				
toluene	99	1	2.20E-07	2.9E-01		7.59E-07	
ethylbenzene	59	1	1.31E-07	9.7E-02		1.35E-06	
xylenes	180	1	4.00E-07	1E-02		4.00E-05	
chlorobenzene	100	1	2.22E-07	2.7E-02		8.23E-06	
bis(2-ethylhexyl)phthalate	5700	1	1.27E-05	6E-01		2.11E-05	
di-n-octyl phthalate	570	1	1.27E-06				
di-n-butyl phthalate	110	1	2.44E-07	1.26E+00		1.94E-07	
butylbenzyl phthalate	420	1	9.33E-07				
fluoranthene	180	1	4.00E-07	6E-03		6.67E-05	
pyrene	110	1	2.44E-07				
Carcinogenic Effects							
tetrachloroethene	22	1	4.59E-10		6E-02		2.76E-11
Total:						1.39E-04	2.76E-11

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

	Hazard Index (Noncarcinogenic Effects)		Estimated Lifetime Cancer Risk	
	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration
Child				
• Dermal exposure	4.0×10^{-4}	1.29×10^{-3}	2.4×10^{-10}	6.61×10^{-10}
• Accidental Ingestion	3.85×10^{-9}	1.39×10^{-4}	1.0×10^{-11}	2.76×10^{-11}
Adult				
• Dermal exposure	1.56×10^{-4}	5.06×10^{-4}	2.05×10^{-9}	5.64×10^{-9}

The hazard indices calculated for exposure are less than 1 indicating the potential for noncarcinogenic effects is minimal. The estimated lifetime carcinogenic risks range from 10^{-9} to 10^{-11} . These estimates suggest a relatively low potential carcinogenic risk following exposure under present site conditions. A significant degree of soil disturbance at some future time may increase risks to receptors.

6.5.1.3 Air

Scenarios developed for exposure to ambient air consider a potential residential receptor located 600 feet from the site who may be exposed to airborne vapors and particulates 24 hours per day, and a receptor who works on the site who may be exposed 8 hours per day for 20 years.

Quantitative estimates of the potential for noncarcinogenic effects and lifetime carcinogenic risks are presented in Tables 6-32 and 6-33. The results are summarized below.

	Hazard Index (Noncarcinogenic Effects)	Estimated Lifetime Cancer Risk
Residential Receptor		
• Inhalation of vapors and particulates	1.92×10^{-5}	6.86×10^{-9}
Onsite Receptor		
• Inhalation of vapors and particulates	2.46×10^{-4}	2.50×10^{-8}

Table 6-32
Estimated Health Effects
Inhalation of Vapors and Particulates
Residential Receptor (600 feet Downwind) - 24 hr/day Exposure
Reich Farm Site

Compound	Conc. (ug/m3)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	1.6E-03	1	4.57E-07	3E+00		1.52E-07	
2-butanone	6.2E-04	1	1.77E-07	2.19E-01		8.09E-07	
chlorobenzene	3.5E-04	1	1.00E-07	5.7E-03		1.75E-05	
ethylbenzene	1.1E-04	1	3.14E-08	9.7E-02		3.24E-07	
xylene	3.2E-04	1	9.14E-08	4E-01		2.29E-07	
toluene	6.5E-04	1	1.86E-07	1.5E+00		1.24E-07	
1,1,1-trichloroethane	6.9E-04	1	1.97E-07	6.3E+00		3.13E-08	
trans-1,2-dichloroethene	2.1E-05	1	6.00E-09				
bis(2-ethylhexyl) phthalate	1.2E-07	1	3.43E-11	6E-01		5.71E-11	
di-n-butyl phthalate	3.3E-09	1	9.43E-13	1.26E+00		7.48E-13	
di-n-octyl phthalate	1.3E-08	1	3.71E-12				
butyl benzyl phthalate	1.5E-08	1	4.29E-12				
fluoranthene	1.1E-09	1	3.14E-13	6E-03		5.24E-11	
pyrene	6.4E-10	1	1.83E-13				
Carcinogenic Effects							
tetrachloroethene	4E-04	1	1.14E-07		6E-02		6.86E-09
Total:						1.92E-05	6.86E-09

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

Table 6-33
Estimated Health Effects
Inhalation of Vapors and Particulates
Onsite Receptor - 8 hr/day Exposure
Reich Farm Site

Compound	Conc. (ug/m3)	Absorbed Fraction	Estimated Dose (mg/kg-day)	ADI (mg/kg-day)	CPF (kg-day/mg)	Estimated Fraction of ADI	Estimated Lifetime Cancer Risk
Noncarcinogenic Effects							
acetone	6.9E-03	1	5.91E-06	3E+00		1.97E-06	
2-butanone	2.6E-03	1	2.23E-06	2.19E-01		1.02E-05	
chlorobenzene	1.5E-03	1	1.29E-06	5.7E-03		2.26E-04	
ethylbenzene	4.7E-04	1	4.03E-07	9.7E-02		4.15E-06	
xylene	1.3E-03	1	1.11E-06	4E-01		2.79E-06	
toluene	2.8E-03	1	2.40E-06	1.5E+00		1.60E-06	
1,1,1-trichloroethane	2.9E-04	1	2.49E-07	6.3E+00		3.15E-08	
trans-1,2-dichloroethene	8.9E-05	1	7.63E-08				
bis(2-ethylhexyl) phthalate	5.9E-07	1	5.06E-10	6E-01		8.43E-10	
di-n-butyl phthalate	1.6E-08	1	1.37E-11	1.26E+00		1.09E-11	
di-n-octyl phthalate	5.5E-08	1	4.71E-11				
butyl benzyl phthalate	6.6E-08	1	5.66E-11				
fluoranthene	5.2E-09	1	4.46E-12	6E-03		7.43E-10	
pyrene	3.1E-09	1	2.66E-12				
Carcinogenic Effects							
tetrachloroethene	1.7E-03	1	4.16E-07		6E-02		2.50E-08
Total:						2.46E-04	2.50E-08

Notes: ADI - Acceptable Daily Intake
CPF - Carcinogenic Potency Factor

The results indicate the potential adverse health impacts from inhalation under present site conditions are minimal. Disturbance of onsite soils may increase the potential risks to both onsite and offsite receptors.

6.5.2 Environmental Impacts

Because of onsite activities by the L-Ed Construction Company the site would provide only marginal habitat for indigenous wildlife. Noise and onsite truck activity would disturb most wildlife. No vegetation exists on site. Terrestrial biota most likely impacted are small mammals, rodents, and indigenous birds.

Exposure to terrestrial wildlife would most likely occur via direct contact (dermal exposure and ingestion) or indirectly in the food chain. Biota could be exposed to HSL organic constituents detected in surface soils or ambient air.

Since biological sampling or environmental surveys were not conducted during the RI, limited conclusions on dose levels or changes in ecosystem composition (species abundance or diversity) can be made. However, none of the contaminants detected in surface soils are present at levels likely to impact terrestrial wildlife. In addition, the contaminants identified do not bioaccumulate or bioconcentrate in the tissues of exposed biota. PAHs and phthalate esters may bioconcentrate, although these compounds are metabolized by most species. Consequently, adverse impacts to terrestrial biota are not expected.

6.5.3 Public Welfare

The major impact on public welfare is the loss of groundwater aquifers as a source of drinking water. Degradation of environmental quality and aesthetic factors are also a consideration.

6.6 Summary

A summary of the health and environmental risks associated with the Reich Farm Site is presented to focus the evaluation. Table 6-34 summarizes the quantitative estimates of noncarcinogenic and carcinogenic risks to human receptors potentially exposed to hazardous constituents.

The major potential health risk is associated with exposure to groundwater. Although there are no data that indicate receptors are exposed to site-associated hazardous constituents, long-term

TABLE 6-34

**SUMMARY OF ESTIMATED HEALTH EFFECTS
REICH FARM SITE**

Exposure Pathway	Range of Hazard Indices (Noncarcinogenic Effects)	Range of Carcinogenic Risks
<u>Groundwater (Monitoring Wells)</u>		
Ingestion	1.0×10^{-2} - 3.4×10^{-1}	3.06×10^{-6} - 1.59×10^{-5}
Inhalation during showering	2.69×10^{-4} - 1.28×10^{-3}	4.62×10^{-6} - 2.36×10^{-5}
Dermal exposure during bathing	1.85×10^{-6} - 8.2×10^{-6}	4.63×10^{-9} - 2.41×10^{-8}
<u>Groundwater (Municipal Wells)</u>		
Ingestion	7.22×10^{-2} - 6.01×10^{-1}	5.48×10^{-7} - 4.46×10^{-6}
Inhalation during showering	6.41×10^{-4} - 3.75×10^{-3}	6.83×10^{-7} - 5.2×10^{-6}
Dermal exposure during bathing	2.66×10^{-6} - 1.43×10^{-5}	8.3×10^{-10} - 6.74×10^{-9}
<u>Groundwater (Residential Wells)⁽¹⁾</u>		
Ingestion	2.65×10^{-4} - 1.61	4.06×10^{-5} - 1.22×10^{-2}
Inhalation during showering	1.02×10^{-3} - 1.89×10^{-2}	2.69×10^{-6}
Dermal exposure during bathing	4.7×10^{-6} - 1.29×10^{-4}	1.84×10^{-6}
<u>Surface Soil</u>		
Dermal contact - child	4.0×10^{-4} - 1.29×10^{-3}	2.4×10^{-10} - 6.61×10^{-10}
Inadvertent ingestion - child	3.85×10^{-7} - 1.39×10^{-4}	1.0×10^{-11} - 2.76×10^{-11}
Dermal contact - adult	1.56×10^{-4} - 5.06×10^{-4}	2.05×10^{-9} - 5.64×10^{-9}
<u>Air</u>		
● Residential Receptor - Inhalation of vapors and particulates	1.92×10^{-5}	6.86×10^{-9}
● Onsite Receptor - Inhalation of vapors and particulates	2.46×10^{-4}	2.50×10^{-8}

Note: (1) Range of effects estimated for all residential well samples.

ingestion or inhalation of the concentrations detected in monitoring well samples may be associated with a carcinogenic risk. However, groundwater use in the immediate site vicinity is restricted. Acute and chronic health effects are unlikely. Exposure to contaminants detected in residential and municipal well samples is of concern although the source of these compounds has not been established. Direct contact with onsite surface soils and inhalation of ambient air pose relatively low risks to potential receptors.

Environmental receptors are unlikely to be impacted by site-associated hazardous constituents. The relatively low concentrations of contaminants identified in surface soil samples suggests the potential for adverse effects to terrestrial wildlife are minimal.